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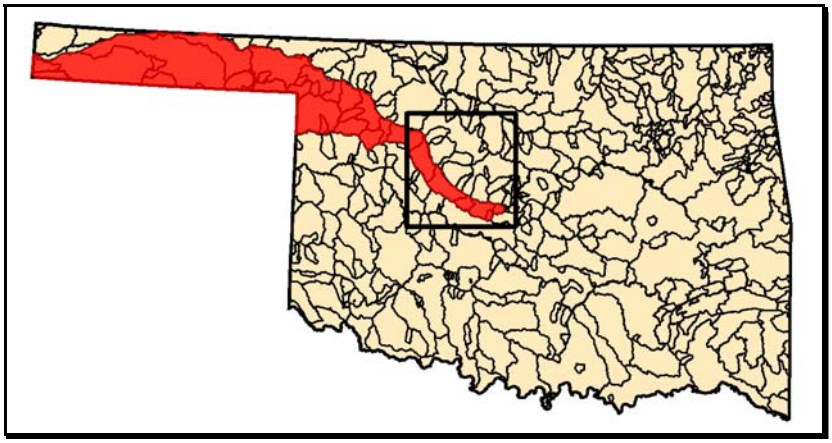
BACTERIA TOTAL MAXIMUM DAILY LOADS FOR NORTH CANADIAN RIVER AND SHELL CREEK, IN THE NORTH CANADIAN RIVER BASIN, OKLAHOMA (OKWBID 52053)



Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

AUGUST 2005

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BACTERIA TOTAL MAXIMUM DAILY LOADS FOR NORTH CANADIAN RIVER AND SHELL CREEK, IN THE NORTH CANADIAN RIVER BASIN, OKLAHOMA (OKWBID 52053)

OKWBID:
520530000010 AND 520530000030

Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

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AUGUST 2005

Oklahoma Department of Environmental Quality: FY01 Section 104(b)(3) Grant #X986883-01 Pathogen Source ID GIS Tool & Pathogen TMDL Development

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ACRONYMS AND ABBREVIATIONS

CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony-forming units
CWA	Clean Water Act
DMR	Discharge monitoring report
HUC	Hydrologic unit code
LA	Load allocation
LDC	Load duration curve
mg	Million gallons
mgd	Million gallons per day
ml	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NSFC	National Small Flows Clearinghouse
ODEQ	Oklahoma Department of Environmental Quality
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
PBCR	Primary body contact recreation
PRG	Percent reduction goal
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	Wasteload allocation
WQC	Water quality criterion
WQM	Water quality monitoring
WQS	Water quality standard
WWTP	Wastewater Treatment Plant

SECTION 1
INTRODUCTION

1.1 TMDL Program Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDL) for water bodies not meeting designated uses where technology-based controls are in place. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (USEPA 1991).

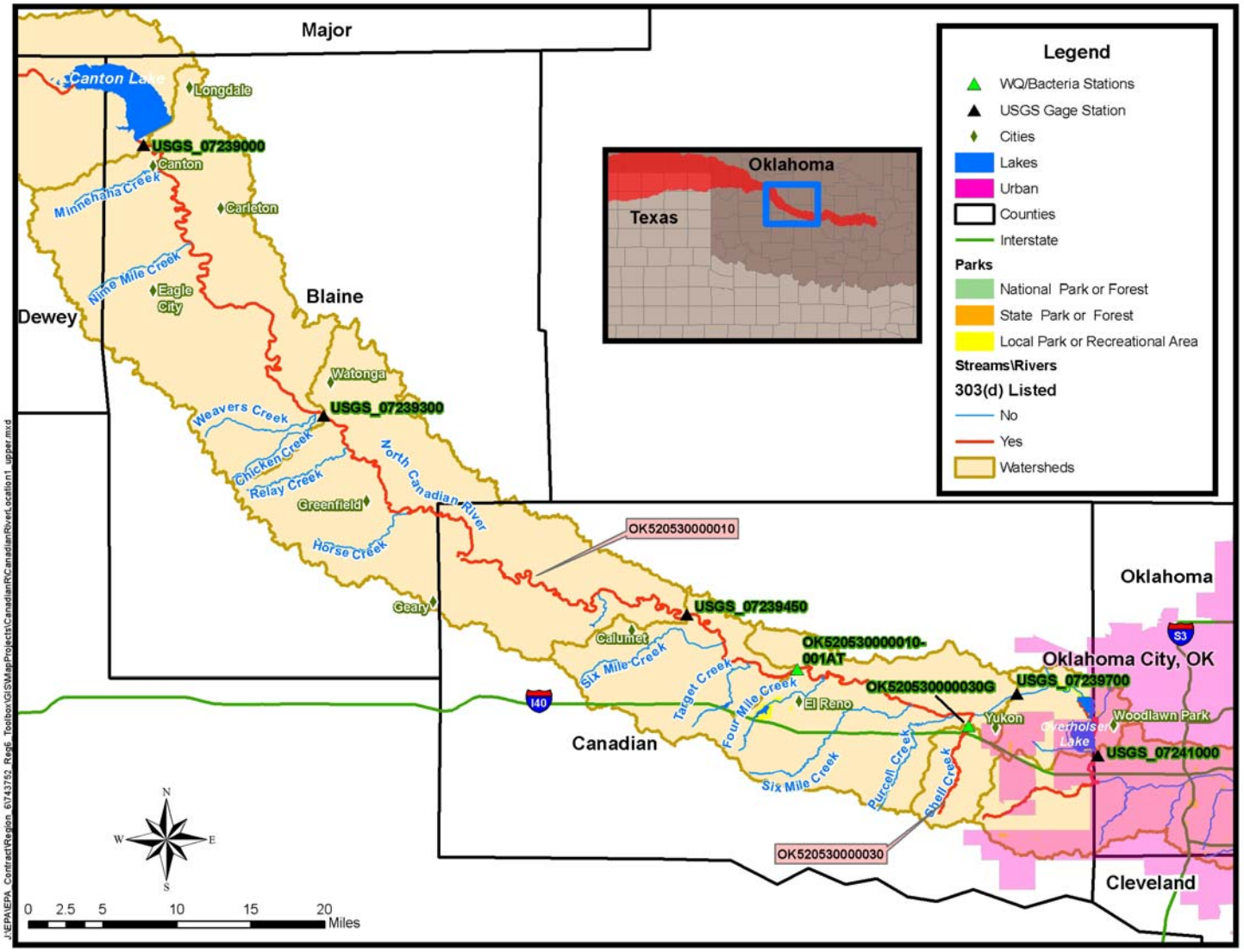
This report documents the data and assessment utilized to establish TMDLs for fecal coliform, *E. coli,* and Enterococcus bacteria for certain water bodies in the North Canadian River Basin in accordance with the requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once USEPA approves a TMDL, then the water body may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2004).

The purpose of this TMDL report is to establish pollutant load allocations for bacteria in impaired water bodies which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a water body can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a water body based on the relationship between pollutant sources and in-stream water quality conditions. A TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that is set aside to account for the uncertainty associated with natural process in aquatic systems, model assumptions and data limitations.

This report does **not** stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria loadings within each watershed. Watershed specific control actions and management measures will be identified, selected, and implemented under a separate process involving stakeholders that live and work in the watersheds, tribes, and local, state and federal government agencies.

This TMDL report focuses on two water bodies ODEQ placed in Category 5 of the 2002 Integrated Report [303(d) list], OK520530000010_10 North Canadian River and OK520530000030 Shell Creek for nonsupport of primary body contact recreation (PBCR). Figure 1-1 is a location map showing the contributing watersheds associated with OK520530000010_10 North Canadian River and OK520530000030 Shell Creek and the water

Figure 1-1 Location Map for North Canadian and Shell Creek Watersheds



quality monitoring (WQM) stations that were used as the basis for placement on the Oklahoma 303(d) List.

Table 1-1 below provides a description of the location of the 303(d)-listed WQM stations. Elevated levels of bacteria in aquatic environments indicate the receiving water is contaminated with human or animal fecal material. Excessive bacteria contamination is an indication that a potential health risk exists for individuals exposed to the water and resulted in the requirement for a TMDL to be developed. Implementation of fecal coliform bacteria loading controls will be necessary to restore the primary contact recreation use designated for each water body listed in Table 1-1.

Table 1-1 Water Quality Monitoring Stations used for 2002 303(d) Listing Decision

Water Body Name	WQM Station Identification Number	WQM Station Locations
North Canadian River	OK520530000010-001AT	North Canadian River at US 81 near El Reno
Shell Creek	OK520530000030G	Shell Creek north of IH-40 near Yukon

1.2 Watershed Description

General. The North Canadian River Basin is located in the west central portion of Oklahoma. Headwaters of the North Canadian River originate in the northwestern region of Oklahoma at Fort Supply Lake and flows in a southeasterly direction towards Oklahoma City. This TMDL report however only focuses on Shell Creek and the North Canadian River downstream of Canton Lake to the confluence of the North Canadian River and Shell Creek. Along this 105 mile reach the North Canadian River accepts drainage from various creeks and swamps, including Minnehala Creek, Ninemile Creek, Weavers Creek, Chicken Creek, Relay Creek, Horse Creek, Sixmile Creek, Target Creek, Fourmile Creek, Purcell Creek, Wilshire Creek and Shell Creek. Water bodies in Blaine and Canadian Counties will be affected by these TMDLs. Canadian and Blaine County are part of the Central Great Plains ecoregion, encompassing some of the best agricultural lands in Oklahoma.

Land Use. Table 1-2 summarizes the acreages and the associated percentages of the land use categories within the contributing watersheds upstream of each WQM station. There are 483,916 acres in the North Canadian River watershed (OK52030000010-001AT), and 14,286 acres in the Shell Creek watershed (OK52030000030G). The land use/land cover data were derived from 1996 U.S. Geological Survey (USGS) Multi-Resolution Land Characteristic land use data (USGS 2005).

Figure 1-2 depicts the land use categories within the North Canadian River and Shell Creek watersheds. The North Canadian River watershed is predominately grassland (51 percent), small grains (27 percent) and row crops (14 percent). The Shell Creek watershed is comprised of grassland (19 percent), small grains (59 percent), pastureland (13 percent) and forest (3 percent). Residential and commercial/industrial land use are insignificant accounting for less than 2 percent in both the North Canadian River and Shell Creek watersheds.

Climate. The average annual precipitation in Oklahoma County ranges from 33 inches in the northern region of the County to 39 inches in the southeast. The average precipitation in

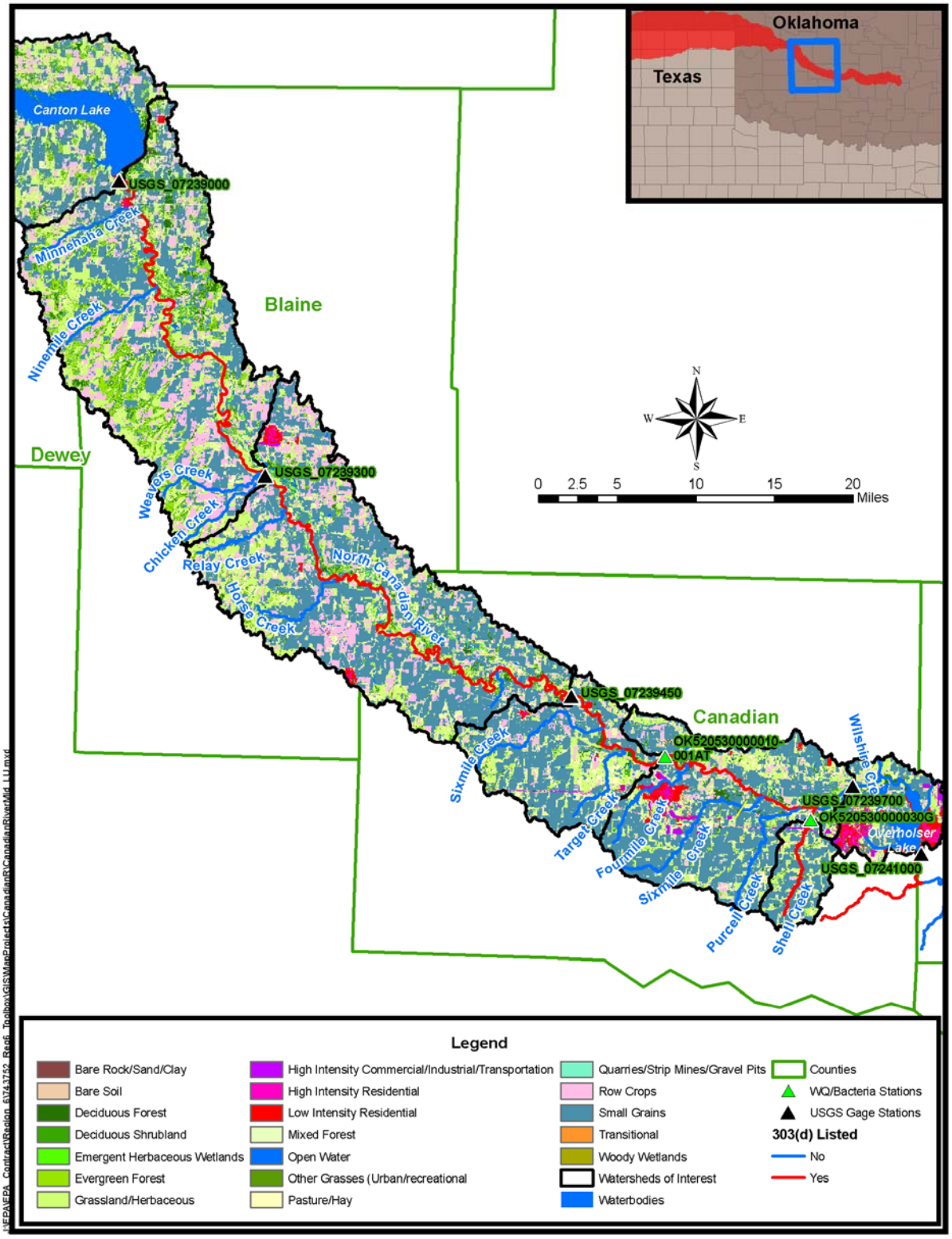
Blaine County ranges from 27 inches in the western region of the county to 33 inches in the east (Oklahoma Climate Survey, 2005).

Table 1-2 Land Use Summary for the North Canadian and Shell Creek Watersheds

	WQM Station	
Landuse Category	**OK52030000010-001AT**	**OK520530000030G**
Percent Open Water	2.47	0.81
Percent Perennial Ice/Snow	0.00	0
Percent Low Intensity Residential	0.33	0.02
Percent High Intensity Residential	0.10	0
Percent High Intensity Commercial/Industrial/Transportation	0.15	1.31
Percent Bare Rock/Sand/Clay	0.08	0.01
Percent Quarries/Strip Mines/Gravel Pits	0.00	0
Percent Transitional	0.00	0
Percent Deciduous Forest	3.37	2.67
Percent Evergreen Forest	4.59	0.97
Percent Mixed Forest	0.97	0.28
Percent Deciduous Shrubland	4.70	1.05
Percent Planted/Cultivated (orchards, vineyards, groves)	0.00	0
Percent Grassland/Herbaceous	23.73	19.16
Percent Pasture/Hay	7.73	13.17
Percent Row Crops	14.35	1.93
Percent Small Grains	35.92	58.6
Percent Bare Soil	0.00	0
Percent Other Grasses (Urban/recreational)	0.00	0.01
Percent Woody Wetlands	0.24	0
Percent Emergent Herbaceous Wetlands	1.27	0
Acres Open Water	12,053	116
Acres Perennial Ice/Snow	0	0
Acres Low Intensity Residential	1,626	3
Acres High Intensity Residential	470	0
Acres High Intensity Commercial/Industrial/Transportation	751	187
Acres Bare Rock/Sand/Clay	370	1
Acres Quarries/Strip Mines/Gravel Pits	0	0
Acres Transitional	0	0
Acres Deciduous Forest	16,449	381
Acres Evergreen Forest	22,412	138
Acres Mixed Forest	4,759	40
Acres Deciduous Shrubland	22,954	150
Acres Planted/Cultivated (orchards, vineyards, groves)	0	0
Acres Grassland/Herbaceous	115,865	2,738
Acres Pasture/Hay	37,724	1,881
Acres Row Crops	70,049	276
Acres Small Grains	175,352	8,372
Acres Bare Soil	1	0

	WQM Station	
Landuse Category	**OK52030000010-001AT**	**OK520530000030G**
Acres Other Grasses (Urban/recreational)	12	2
Acres Woody Wetlands	1,177	0
Acres Emergent Herbaceous Wetlands	6,181	0
Total (Acres)	**488,204**	**14,286**

Figure 1-2 Land Use Map for North Canadian and Shell Creek Watersheds



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Description of State Water Quality Standards

Title 785 of the Oklahoma Administrative Code authorizes the Oklahoma Water Resources Board (OWRB) to promulgate Oklahoma's Water Quality Standards (OWRB 2004). The Oklahoma Water Resources Board has statutory authority and responsibility concerning the establishment of state water quality standards, as provided for under 82 O.S., §1085.30. This statute authorizes the Oklahoma Water Resources Board to promulgate rules *which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters [82:1085:30(A)].* Beneficial uses are designated for all waters of the state. Such uses are protected through the restrictions imposed by the antidegradation policy statement, narrative criteria and numerical standards (OWRB 2004). The beneficial uses designated for the North Canadian River Basin and Shell Creek include Primary Body Contact Recreation (PBCR), Fish Consumption, Warm Water Aquatic Community, Industrial Aesthetics, and Agriculture. The TMDLs in this report only address the PBCR designated use. The North Canadian River and Shell Creek are **not** designated as Oustanding Resource, Scenic Waters or high quality waters in Appendix A of the WQS. Table 2-1 summarizes the beneficial use attainment status for North Canadian River and Shell Creek as summarized in Appendix B of the 2002 Integrated Report (ODEQ 2002).

Table 2-1 Excerpt from the 2002 Integrated Report – Comprehensive Waterbody Assessment Category List

OKWBID	NAME	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation	Warm Water Aquatic Community
OK520530000010_10	Canadian River, North	101	5	2005	N	N
OK520530000030_00	Shell Creek	9	5	2006	N	N

A = Attaining I = Insufficient Data N = Not Attaining X = Not Assessed

Source: 2002 Integrated Report, ODEQ 2002

The definition of PBCR is summarized by the following excerpt from Chapter 45 of the Oklahoma WQS.

> *(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.*

(b) In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

Oklahoma's numeric criteria to protect the PBCR beneficial use are (OWRB 2004):

(1) Coliform Bacteria: The bacteria of the fecal coliform group shall not exceed a monthly geometric mean of 200/100 ml, as determined by multiple-tube fermentation or membrane filter procedures based on a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. Further, in no more than 10% of the total samples during any thirty (30) day period shall the bacteria of the fecal coliform group exceed 400/100 ml.

(2) Escherichia coli (E. coli): E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. No sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas.

(3) Enterococci: Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. No sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas.

Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the three bacteria indicators. However, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group shall demonstrate compliance with the numeric criteria prescribed (OWRB 2004).

As stipulated in the WQS, utilization of the geometric mean to determine compliance for any of the three indicator bacteria depends on the collection of 5 samples within a 30 day period. For most WQM stations in Oklahoma there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, most of the waterbodies placed on the 303(d) list for not supporting the PBCR are the result of noncompliance with the instantaneous criterion associated with the different indicator bacteria. Targeting the instantaneous criterion as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and is expected to be protective of the geometric mean criterion as well.

2.2 Problem Identification

Table 2-2 summarizes water quality data for each bacteria indicator (if available) collected between 1997 and 2001 supporting the decision to place the North Canadian River and Shell Creek on the ODEQ 2002 303(d) list (ODEQ 2002a). The number of exceedances is derived from a comparison of the existing water quality data to the instantaneous criterion for each bacteria indicator. To reflect more recent water quality conditions, Table 2-3 summarizes data collected between 1997 and 2003. Water quality data from the primary contact recreation season (May 1 through September 30) for each WQM station from 1997 to 2003 (if available) are provided in Appendix A. Ambient fecal coliform data were provided by ODEQ and obtained from USEPA Storage and Retrieval Database (USEPA 2005).

Table 2-2 Bacteria Samples from 1997 through 2001

WQM Station	Water Body Name	Bacteria	Water Quality Criterion	Maximum Concentration (Cfu/100ml)	Number of Samples	Number of Samples Exceeding Criterion	% of Samples Exceeding Criterion
USGS_07239450	North Canadian River	FC	400	3700	26	5	19
OK520530000010-001AT	North Canadian River	FC	400	4100	26	5	19
OK520530000030G	Shell Creek	EC	406	959	6	1	17
OK520530000030G	Shell Creek	ENT	108	1100	5	5	100
OK520530000030G	Shell Creek	FC	400	5000	8	4	50

Table 2-3 Bacteria Samples from 1997 through 2003

WQM station	Water Body Name	Bacteria	Water Quality Criterion	Maximum Concentration (Cfu/100 ml)	Number of Samples	Number of Samples Exceeding Criterion	% of Samples Exceeding Criterion
USGS_07239450	North Canadian River	FC	400	3700	30	7	23
OK520530000010-001AT	North Canadian River	EC	406	120	13	0	0
OK520530000010-001AT	North Canadian River	ENT	108	6000	13	11	85
OK520530000010-001AT	North Canadian River	FC	400	4100	26	5	19
OK520530000030-001AT	Shell Creek	EC	406	959	6	1	17
OK520530000030-001AT	Shell Creek	ENT	108	1100	5	5	100
OK520530000030-001AT	Shell Creek	FC	400	5000	8	4	50

For the data collected between 1997 and 2001, violations with respect to the fecal coliform criterion occurred in all three WQM stations of the study area. Shell Creek also demonstrated nonsupport of the PBCR use based on the *E. coli* and enterococcus criteria. For the data collected between 1997 and 2003, violations with respect to the fecal coliform criterion occurred in all three WQM stations of the study area. The North Canadian River also did not support PBCR use based on the enterococcus criterion. Shell Creek did not support the PBCR use based on the *E. coli* and enterococcus criteria. An insufficient data set was available to compare to the geometric mean criteria.

The consistent percentage of water quality criterion exceedances in Shell Creek, regardless of the bacteria indicator, suggests that the temporal and spatial severity of bacteria loading is significant and chronic and may be a function of the small size of the watershed and the low or intermittent flow. Conversely the temporal and spatial severity of bacteria loading is more difficult to demonstrate along the entire reach of the North Canadian River given the size of the watershed, the lack of synoptic data from WQM stations on the main stem of North Canadian River, and no bacteria data from tributaries to the North Canadian River. With no enterococci data upstream at USGS gage station 07239450 to compare to the downstream WQM station OK520530000010-001AT, it is difficult to determine conclusions and relationships between bacteria concentrations and source contributions along the North Canadian River.

2.3 Water Quality Target

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." For the WQM stations requiring TMDLs in this report, defining the water quality target is somewhat complicated by the use of three different bacteria indicators with three different numeric criterion for determining the attainment of the PBCR use as defined in the Oklahoma WQSs. As previously stated, because available bacteria data were collected on an approximate monthly basis (See Appendix A) instead of at least five samples over a 30–day period, data for these TMDLs are analyzed and presented in relation to the instantaneous criteria for each of the three bacteria indicators. Furthermore these TMDLs must take into account that no more than 10 percent of the samples can exceed the instantaneous numeric criteria. Rather than propose TMDL calculations for all bacteria indicators at each WQM station, water quality targets for TMDL development will be driven by one indicator for each water body based on which ever bacteria indicator is the most conservative (i.e., warrants the largest percent reduction). Furthermore, the water quality target for each impaired WQM station will incorporate an explicit 10 percent MOS. For example if fecal coliform is utilized to establish the TMDL then the water quality target will be 360 cfu/100 ml which is 10 percent lower than the instantaneous water quality criteria of 400 cfu/100 ml. For *E. coli* the water quality target will be 365.4 cfu/ 100 ml which is 10 percent lower than the criterion value (406 cfu/100 ml). For Enterococci the water quality target will be 97.2 cfu/100 ml which is 10 % lower than the criterion value (108 cfu/ 100 ml). This conservative approach will be protective of both the instantaneous and 30-day geometric mean criteria.

This water quality target will be used to determine the allowable bacteria load which is derived by using the actual or estimated flow record multiplied by the instream criteria minus a 10 percent MOS. The line drawn through the allowable load data points is the water quality target which represents the maximum load for any given flow that still satisfies the WQS.

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A source assessment characterizes known and suspected sources of pollutant loading to impaired water bodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from warm-blooded animals and some plant life and sources may be point or nonpoint in nature.

Point sources are permitted through the National Pollutant Discharge Elimination System (NPDES) program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for of one of the three bacteria indicators (fecal coliform, *E. coli*, or Enterococcus) in accordance with their permit. Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body through a discrete conveyance at a single location. These sources may involve land activities that contribute bacteria to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds.

3.1 NPDES-Permitted Point Sources

Under 40CFR§122.2, a point source is described as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges that may contribute bacteria loading include:

1. NPDES municipal wastewater treatment plants (WWTP);
2. NPDES municipal separate storm sewer discharges (MS4s); and
3. NPDES Concentrated Animal Feeding Operations (CAFOs).

Continuous point source discharges such as WWTPs, could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Program, can also contain high fecal coliform bacteria concentrations. However, there are no urbanized areas designated as MS4s in the North Canadian River or Shell Creek watersheds.

3.1.1 Continuous Point Source Discharges

Table 3-1 lists the one NPDES-permitted WWTP located in the North Canadian River watershed in the City of Watonga WWTP. There are no continuous point source discharges in the Shell Creek watershed. The location of the active NPDES facility upstream of WQM station OK520530000010-001AT is shown in Figure 3-1. Discharge Monitoring Reports (DMR) were used to determine the number of fecal coliform analyses performed from 1998 through 2003, the maximum concentration during this period, the number of violations occurring when the monthly geometric mean concentration exceeded 200 cfu/100 ml, and the number of violations when a daily concentration exceeded 400 cfu/100 ml. The DMR data for each WWTP are provided in Appendix B. For the most part, these data indicate only occasional fecal coliform permit violations occurring at the WWTP listed in Table 3-1.

In 1998, 60 percent of the samples from the City of Watonga WWTP exceeded the daily and monthly average permit limit for fecal coliform. In 2000, only 20 percent of the samples exceeded the daily and monthly average permit limit.

Figure 3-1 Locations of NPDES-Permitted Facilities in the North Canadian River Watershed (OK52053)

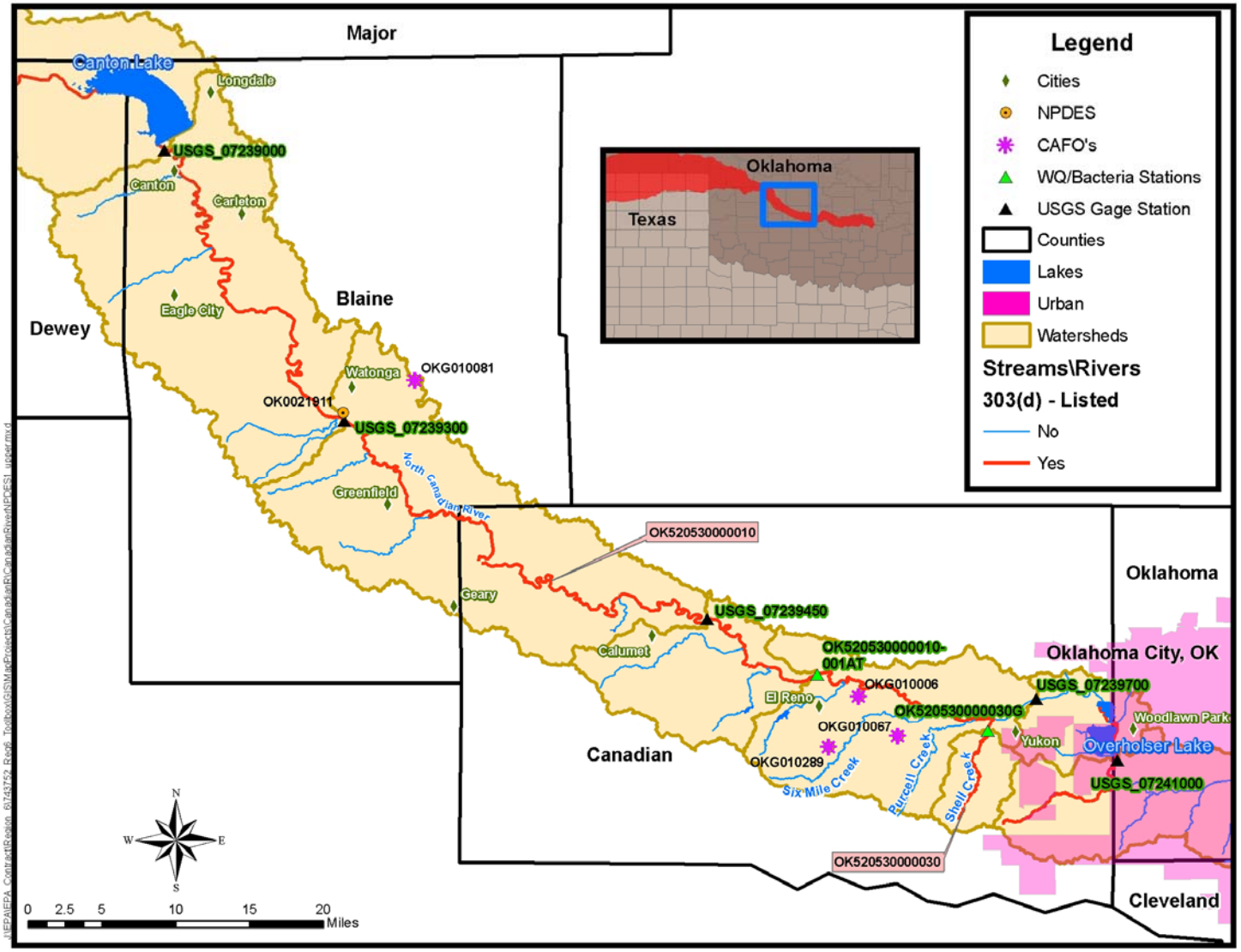


Table 3-1 Permitted WWTPs in the North Canadian River Watershed (OK52053)

NPDES	OK0021911
FACILITY NAME	City of Watonga
LOCATION	WATONGA
RECEIVING WATER	NORTH CANADIAN RIVER OK52053
SIC CODE	SEWERAGE SYSTEMS (4952)
COUNTY	BLAINE
DESIGN FLOW	1.00
MAJOR/MINOR	Major

Sanitary sewer overflows (SSO) from wastewater collection systems, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of the pipes by grease, tree roots and other debris that clog sewer lines. SSOs are permit violations that must be addressed by the responsible NPDES permittee. Across the nation the reporting of SSOs has, within the last 6 years, been strongly encouraged by USEPA, primarily through enforcement and fines. However, currently no data is available to quantify SSOs that may have occurred in sewered areas of the North Canadian River watershed.

3.1.2 Concentrated Animal Feeding Operations (CAFOs)

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their wastes. Through regulations established by the Oklahoma Concentrated Animal Feeding Operation Act, AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the state. A CAFO is an animal feeding operation that confines and feeds 1,000 animal units or more for 45 days or more in a 12 month period (ODAFF 2005). The CAFO Act is designed to protect water quality through the use of best management practices such as dikes, berms, terraces, ditches or other similar structures used to isolate animal waste from outside surface drainage except for a twenty-five year, 24–hour rainfall event (ODAFF 2005). CAFOs are considered no discharge facilities.

CAFOs are designated by USEPA as a significant source of pollution, and may have the potential to cause serious impacts on water quality if not managed properly. Potential problems for CAFOs can include animal waste discharges to waters of the state and failure to properly operate wastewater facilities.

Figure 3-1 above depicts the locations of the four CAFOs located in the North Canadian River watershed. There are no CAFOs located in the Shell Creek watershed. Table 3-2 lists the CAFOs located in the North Canadian River watershed.

Table 3-2 NPDES-Permitted CAFOs in the North Canadian River Watershed (OK52053)

NPDES ID	OKG010081	OKG010289	OKG010006	OKG010067
CAFO Name	WHEELER BROS. GRAIN CO.	JENSEN FEEDLOT	ALFADALE STOCKFARM LLC	OKC WEST LIVESTOCK MARKET
City	WATONGA	EL RENO	EL RENO	EL RENO
County	BLAINE	CANADIAN	CANADIAN	CANADIAN
State/County FIPS	40011	40017	40017	40017
Type of Facility	beef cattle	beef cattle	beef cattle	CS/F-S-H-
# Animals	24,750	2,950	1,500	189,400
License Exp. Date	6/30/2003	6/30/2003	6/30/2003	6/30/2003

There are approximately 51.5 acres of land application area associated with CAFO OKG010289 (ODAFF, 2005a). According to ODAFF, there are no reported historic performance problems from the CAFOs in this region.

3.2 Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the water body at a specific location. Bacteria originate from rural, suburban, and urban areas. The following section describes possible major nonpoint sources contributing fecal coliform in the Shell Creek and North Canadian River watershed. These sources include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems and domestic pets. Runoff from small urban areas not permitted under the MS4 program is probably a significant source of bacteria loading to streams. Bacteria associated with urban runoff can emanate from humans, wildlife, livestock and domestic pets. Water quality data collected from streams draining un-permitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. As previously stated there are no NPDES-permitted facilities in the Shell Creek watershed, therefore nonsupport of the PBCR use is caused by nonpoint sources of bacteria only.

3.2.1 Wildlife

Fecal coliform bacteria are produced by warm blooded animals or feral animals such as deer, feral hogs, raccoons, other small mammals and avian species. This group of animals is often referred to as wildlife. In developing bacteria TMDLs it is important to identify the potential for bacteria contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers and with direct access to the stream channel can be a concentrated source of fecal coliform loading to a water body. Fecal coliform bacteria from wildlife are also deposited onto land surfaces where it can be easily transported during storm events to nearby streams. Currently there are insufficient data available to estimate populations of wildlife and avian species by watershed. Consequently it is difficult to assess the magnitude of bacteria contributions from wildlife species as a general category.

However, adequate data are available by county to estimate the number of deer by watershed. This report assumes that deer habitat includes forests, croplands and pastures. Using Oklahoma Department of Wildlife and Conservation county data the population of deer can be roughly estimated from the number of deer harvested and harvest rate estimates. Because harvest success varies from year to year based on weather and other factors, the average harvest from 1999 to 2003 were combined with an estimated annual harvest rate of 20% to predict deer populations. Table 3-3 provides the estimated number of deer for the North Canadian River and Shell Creek watersheds.

Although only a portion of the total fecal coliform loading produced by the deer population may actually enter a water body, the estimated fecal coliform production for deer provided in Table 3-3 in cfu/day does provide a relative magnitude of loading in each watershed. According to a study conducted by Yagow (1999), fecal coliform production rate for deer is 347 x 10^6 cfu/head-day. Using deer population estimates as an indicator of general wildlife population, wildlife is considered to be a minor contributor of bacteria in the North Canadian River and Shell Creek watersheds.

Table 3-3 Estimated Deer Population

Category	Shell Creek	North Canadian River
Watershed Area (acres)	14,297	483,916
Wild Deer Population	96	1,126
Estimated Wild Deer per acre	0.007	0.002
Fecal Production (cfu/day) of Deer Population	3.32E+10	3.91E+11

3.2.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of bacteria loading. The agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002):

- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can contribute significantly to fecal coliform loading.
- Agricultural livestock grazing in pastures deposit manure containing fecal coliform bacteria onto land surfaces.
- Agricultural livestock and wildlife often have direct access to waterbodies and can provide a concentrated source of fecal loading directly into streams.

According to a livestock study conducted by the American Society of Agricultural Engineers (ASAE 1998), the following fecal coliform production rates were estimated:

- cattle release approximately 100 billion fecal coliform per animal per day;
- horses - 400 million per animal per day;
- pigs - 11 billion per animal per day;
- chickens – 1.4 billion per animal per day;

- turkeys - 1 billion per animal per day; and
- sheep - 12 billion per animal per day

Table 3-4 provides estimated numbers of the different livestock by watershed based on 1997 and 2002 USDA county livestock census data. It is surmised that since most of the mammal species listed below have direct access to tributaries of North Canadian River and to Shell Creek, the potential for concentrated loading of bacteria is likely high.

Table 3-4 Livestock Estimates by Watershed

Livestock	Shell Creek	North Canadian River
Cattle	2,466	71,152
Dairy Cows	30	505
Cattle feedlots	1	10
Horses	68	999
Mules, Burros & Donkeys	1	20
Goats	18	247
Sheep	44	679
Hogs & Pigs	215	1,858
Bison	9	70
Llamas	3	24
Deer & Elk	0	0
Rabbits	5	41
Chickens	29	457
Turkeys	0	5
Ducks & Geese	3	41
Ostrich & Emu	0	0
All Poultry	110	1,282

The following table provides a summary of estimated fecal coliform contributions from a select group of livestock in the North Canadian River and Shell Creek watersheds.

Table 3-5 Fecal Coliform Loading Estimates for Select Livestock

	OK520530000030	OK520530000010
Cattle	1.00E+11	7.12E+15
Horses	4.00E+08	4.00E+11
Sheep	1.20E+10	8.15E+12
Hogs & Pigs	1.10E+10	2.04E+13
Chickens	1.40E+09	6.39E+11
Turkeys	1.00E+09	4.55E+09

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Onsite Wastewater Disposal (OSWD) systems and illicit discharges can be a source of bacteria loading to streams and rivers. Bacteria loading from failing OSWD tanks can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Fecal coliform-contaminated groundwater discharges to creeks through springs and seeps. To estimate the potential magnitude of OSWD systems as a contributor of bacteria loading the number of OSWD systems was estimated for each watershed. The estimate of OSWD systems was derived by using data from the 1990 U.S. Census data.

The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census tract by the number of acres in each census tract. This density was then applied to the number of acres of each census tract within a WQM station watershed. Census tracts crossing a watershed boundary required an additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all the OSWD systems for each whole or partial census tract. Since subdivisions are built on large land tracts (hundreds of acres) the number of OSWD systems per 100 acres is easier to visualize; therefore, the following equation was used to estimate the number of OSWD systems as presented in Table 3-6:

OSWD systems 100 acres = (number of OSWD tanks / number of acres in the watershed) x 100

Table 3-6 Estimate of OSWD Systems per 100 Acres

	OK520530000010	OK520530000030
Number of OSWD Systems	.4	1.5

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger would cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). The 1995 American Housing Survey conducted by the U.S. Census Bureau estimates that, nationwide, 10 percent of occupied homes with OSWD systems experience malfunctions during the year (U.S. Census Bureau 1995).

From the density estimates presented in Table 3-6 OSWD systems are not considered to be a significant source of bacteria loading in either watershed.

Table 3-7 Estimates of Sewered and Unsewered Households

WATERBODY	Public Sewer	Septic tank or cesspool	Other means	Housing Units	%Sewered
OK520530000010	2,880	2,017	80	4977	58%
OK520530000030	166	213	2	381	44%

3.2.4 Domestic Pets

Fecal coliform from dogs and cats transported to streams by runoff from urban and suburban areas can be a potential source of bacteria loading. A study conducted by Weiskel *et al.* (1996) found that pets produce 450 million fecal coliform per animal per day. A study in a Washington, D.C. suburb found that dogs produce approximately 0.42 pounds of fecal waste per day (Thorpe 2003). A comparable number for waste produced by cats was not available.

On average nationally, there are 0.58 dogs per household and 0.66 cats per household (American Veterinary Medical Association (2004). Using the U.S. census data (U.S. Census Bureau 2000), dog and cat populations can be estimated for each watershed. Table 3-8 summarizes the estimated number of dogs and cats for the North Canadian River and Shell Creek watersheds. Given the sparse pet population in both watersheds dogs and cats are not considered to be a major source of bacteria loading.

Table 3-8 Estimated Numbers of Pets

	OK520530000030	OK520530000010
Dogs	221	2,887
Cats	251	3,285

SECTION 4
TECHNICAL APPROACH AND METHODOLOGY

The objective of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. A TMDL is expressed as the sum of three elements as described in the following mathematical equation:

$$TMDL = \Sigma\ WLA + \Sigma\ LA + MOS$$

The wasteload allocation is the proportion of the TMDL allocated to existing and future point sources. The load allocation is the portion of the TMDL allocated to nonpoint sources and natural background sources. The margin of safety is intended to ensure that water quality standards will be met. Thus the allowable pollutant load that can be allocated to point and nonpoint sources can then be defined as the TMDL minus the MOS.

40 CFR § 130.2 (1) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform, *E. coli*, or Enterococcus, TMDLs are expressed as cfu per day where possible or as a percent reduction goal (PRG), and represent the maximum one day load the stream can assimilate while still attaining the WQS.

4.1 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDCs). LDCs facilitate rapid development of TMDLs and as a TMDL development tool, are effective at identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the four following steps which are described in subsections 4.2 through 4.4 below:

i) Preparing flow duration curves for gaged and ungaged WQM stations;
ii) Estimating existing bacteria loading in the receiving water;
iii) Using LDCs to identify the critical condition which will dictate loading reductions necessary to attain WQS; and
iv) Interpreting LDCs to derive TMDL elements – WLA, LA, MOS and PRG

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (e.g., 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address nonpoint sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For water bodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when treatment plant effluents would dominate the base flow of the impaired water.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by the water quality criterion. The TMDL can be

expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

4.2 Development of Flow Duration Curves

Flow duration curves serve as the foundation of load duration curves and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many WQM stations throughout Oklahoma do not have long term flow data and therefore, flow frequencies have to be estimated using a standard drainage area ratio method. The most basic method to estimate flows at an ungaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the ungaged sites and the flow gage; 3) calculating daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio. More complex approaches may also consider watershed differences in rainfall, land use, and the hydrologic properties of soils that govern runoff and retention. More than one upstream watershed may also be considered. A more detailed explanation of the methodology for estimating flow at ungaged WQM stations is provided in Appendix C.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest, then, for each observation, the percentage of observations exceeding that flow is calculated. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa, which is numbered from 0 to 100%, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100% indicating that flow has equaled or exceeded this value 100% of the time, while the highest measured flow is found at an exceedance frequency of 0%. The median flow occurs at a flow exceedance frequency of 50%. The flow exceedance percentiles for each WQM station addressed in this report are provided in Appendix C.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than one year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long term flow gaging stations operated by the U.S. Geological Survey (USGS) are utilized (USGS 2005a).

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow duration of 0% and downward at a frequency near 100%, often with a relatively constant slope in between. For sites that on occasion have exhibited no flow, the curve will intersect the abscissa at a frequency less than 100%. As the number of observations at a site increases, the line of the load duration curve tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantitation.

Figures 4-1 through 4-4 are flow duration curves generated using the automated method described above. The flow duration curve for North Canadian River at the WQM station near El Reno (OK520530000010-001AT) is displayed in Figure 4-2 and was estimated using flow

data from USGS gage station 07239500. The flow duration curve for Shell Creek (OK520530000030G) displayed in Figure 4-3 was estimated using flow data from USGS gage station 07239700. Flow duration curves have also been provided for USGS gage stations 7239450 and 07239700 for informational purposes and are depicted in Figures 4-1 and 4-4 respectively. The periods of records for the USGS 07239700, USGS 07239500, and USGS 07239450 gage stations are from years 1948-1955, 1902-2003, and 1988-2003 respectively.

Figure 4-1 Flow Duration Curve for North Canadian River at USGS Gage 07239450

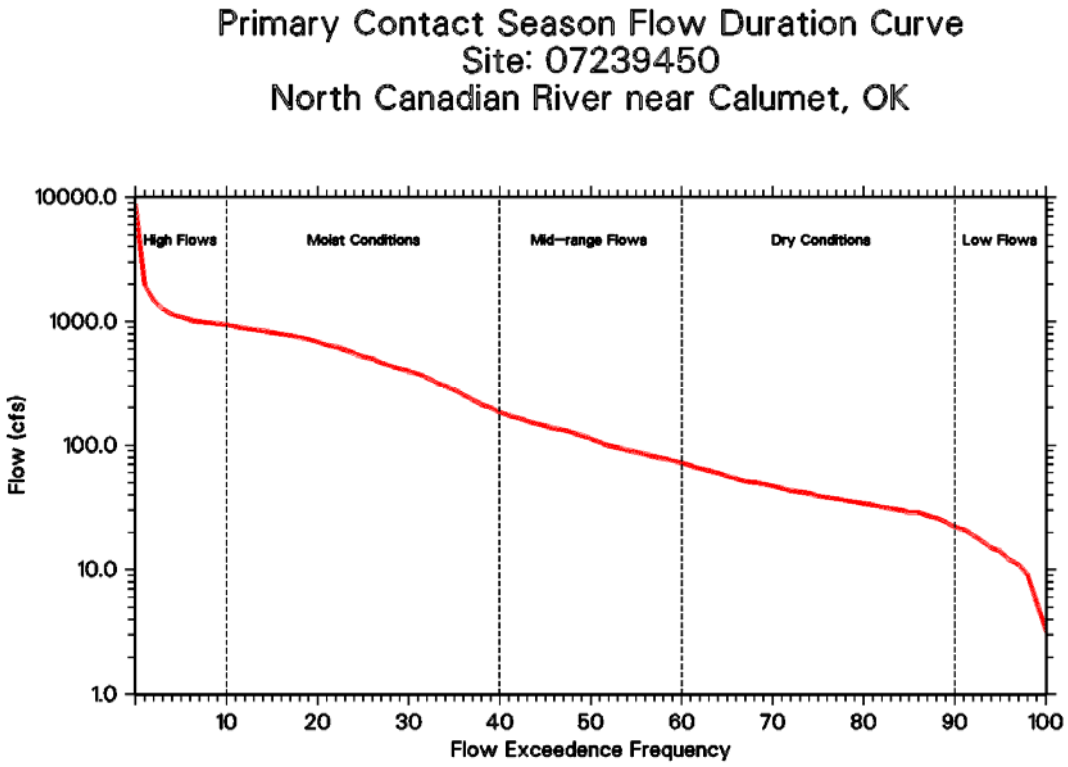


Figure 4-2 Flow Duration Curve for North Canadian River WQM Station OK520530000010-001AT

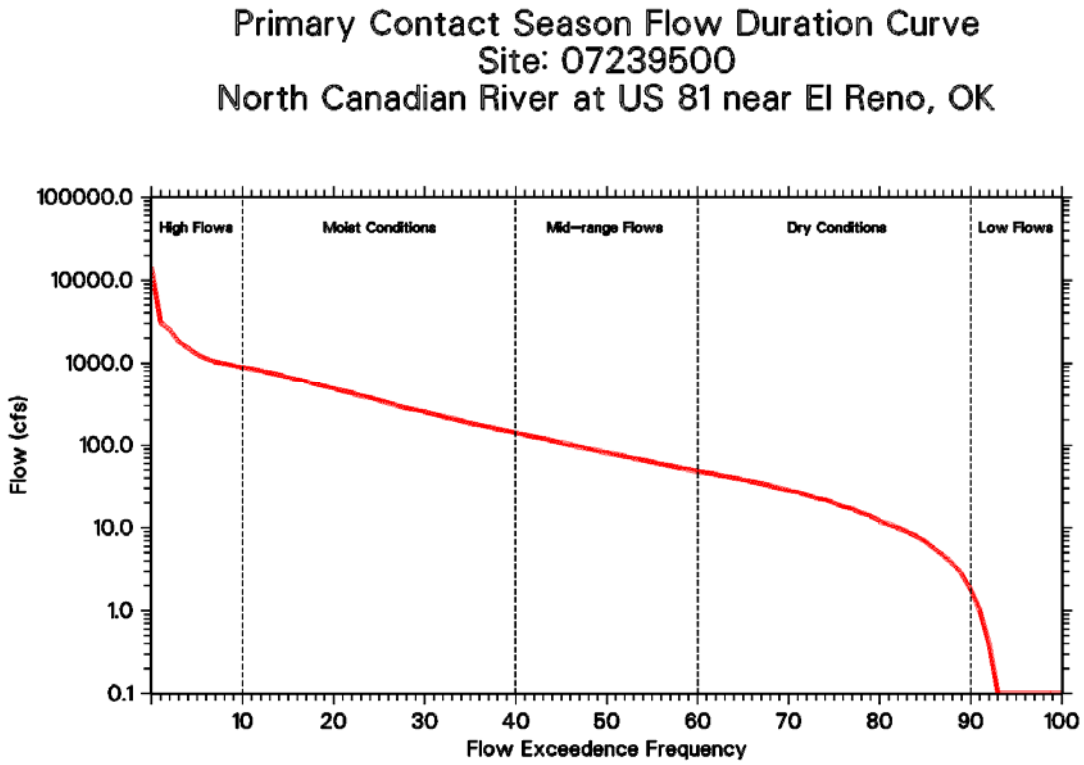
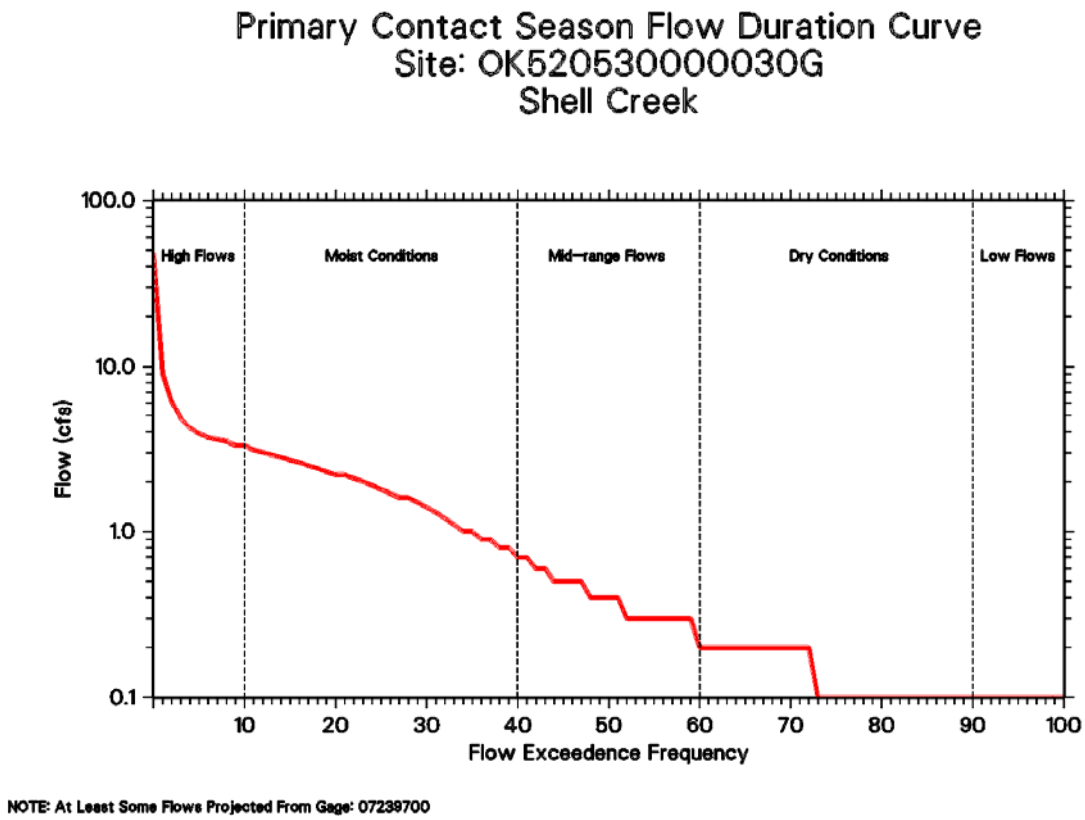
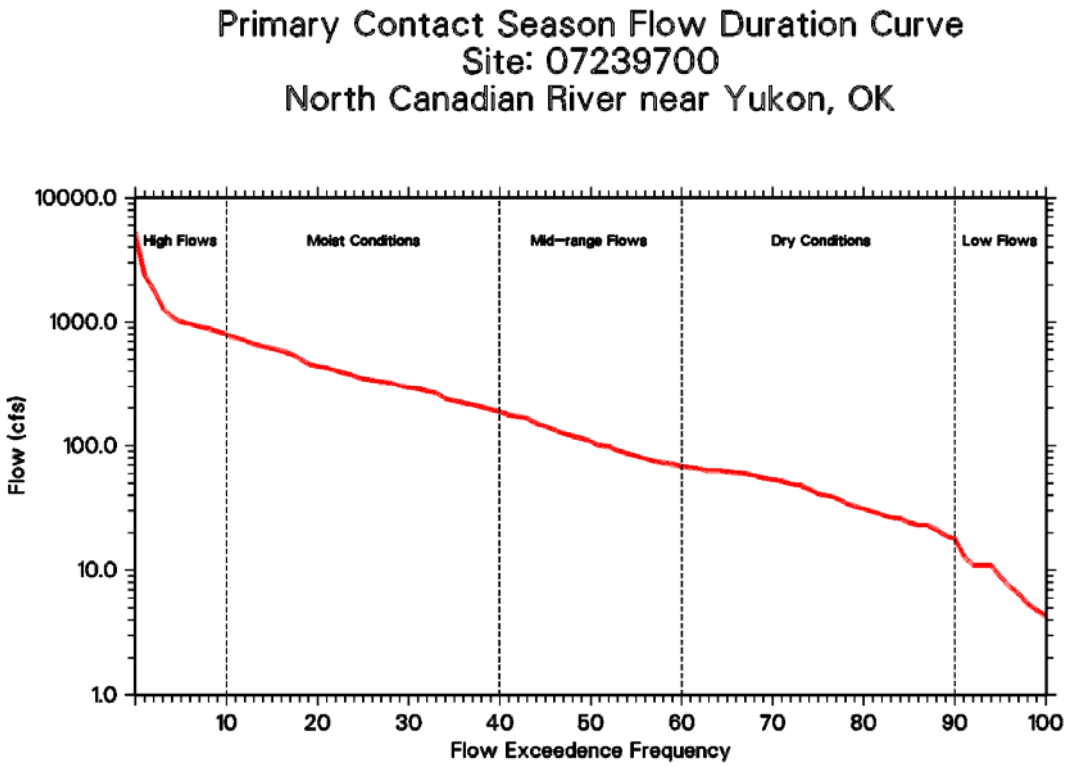


Figure 4-3 Flow Duration Curve for Shell Creek at WQM Station OK520530000030G



The stepped characteristic of the load duration curve at OK520530000030G (Shell Creek) is caused by the extremely low flow conditions typical of this stream. This effect is related to the estimated flow values provided in Appendix C for OK520530000030G, which starting from the 30th flow exceedance percentile are less than 1. At the 69th flow exceedance percentile, the flow is 0.1 cfs or less indicating the stream flow is intermittent. The plotting of the curve using flow values with single digit integers does not have sufficient resolution to display the line as a smooth curve.

Figure 4-4 Flow Duration Curve for North Canadian River at USGS Gage 07239700



ODEQ has chosen to subdivide the flow exceedence range of flow duration curves into five hydrologic condition classes. The hydrologic classes selected facilitate the diagnostic and analytical uses of flow and load duration curves. The hydrologic classification scheme utilized in this application is similar to that described by Cleland (2003):

Table 4-1 Hydrologic Classification Scheme

Flow Duration Interval	Hydrologic Condition Class
0-10%	High flows
10-40%	Moist Conditions
40-60%	Mid-Range Conditions
60-90%	Dry Conditions
90-100%	Low Flows

Flow duration curves are generated using an ODEQ automated application referred to as the bacteria load duration curve toolbox. A step by step procedure on how to generate flow duration curves and flow exceedence percentiles are provided in Appendix C.

The National Water Information System of the U.S. Geological Survey serves as the primary source of flow measurements for the application. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream stations in

adjacent states, were retrieved for use in the application. The application includes a data update module that automatically downloads the more recent USGS data and appends it to the existing flow database.

Some instantaneous flow measurements were available from various agencies. These were not combined with the daily average flows or used in calculating flow percentiles, but were matched to bacteria grab measurements collected at the same site and time. When available, these instantaneous flow measurements were used in lieu of the daily average flow to calculate instantaneous bacteria loads.

4.3 Estimating Current Point and Nonpoint Loading and Identifying Critical Conditions

Another key step in the use of LDCs for TMDL development is the estimation of existing bacteria loading from point and nonpoint sources and the display of this loading in relation to the TMDL line. In Oklahoma, WWTPs that discharge treated sanitary wastewater must meet the state WQS for bacteria at the point of discharge. However, for TMDL analysis it is necessary to understand the relative contribution of WWTPs to the overall pollutant loading and their general compliance with required effluent limits. The bacteria load for continuous point source dischargers is estimated by multiplying the monthly average flow rates by the monthly geometric mean using a conversion factor. The data necessary for this calculation were extracted from each point source's DMR from 1998 through 2004. The 90th percentile value of the monthly loads was used to express the estimated existing load in counts/day. The current pollutant loading from each permitted point source discharge is calculated using the equation below.

*Point Source Loading = monthly average flow rates (mgd) * geometric mean of corresponding fecal coliform concentration * unit conversion factor*

Where:

unit conversion factor = 37,854,120 100-ml/million gallons (mg)

It is difficult to estimate current nonpoint loading due to lack of specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within the watershed. Therefore, existing instream loads were used as a conservative surrogate for nonpoint loading. Estimated existing loading was calculated by multiplying the concentration of bacteria grab samples by the flow matched to the specific sampling date. The period of record for the bacteria data set varies from WQM station to WQM station but only bacteria data after 1997 was used to estimate existing loading. Then using the hydrologic flow intervals, the 90th percentile nonpoint loading within each of the intervals would then represent the nonpoint loading estimate for that interval. Existing loads have been estimated using a regression-based relationship developed between observed fecal coliform loads and flow or flow exceedance percentile.

In many cases, inspection of the LDC will reveal a critical condition related to exceedances of WQSs. For example, criteria exceedances may occur more frequently in wet weather, low flow conditions, or after large rainfall events. The critical conditions are such that if WQSs were met under those conditions, WQSs would likely be met overall. For example, given that the instantaneous fecal coliform criterion indicates that no more than 10 percent of samples should exceed 400 cfu/100 ml, it is appropriate to evaluate existing loading as the 90th

percentile of observed fecal coliform concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

Existing loading is calculated as the 90th percentile of measured fecal coliform concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in calculating the existing loading under dry conditions (flow exceedance percentile = 60-90%), the 75th percentile exceedance flow is multiplied by the 90th percentile of fecal coliform concentrations measured under the 60-90th percentile flows. The "high flow" or "low flow" hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are typically available to reliably estimate loads under these conditions. This methodology results in multiple estimates of existing loading. However, TMDLs are typically expressed as a load or concentration under a single scenario. Therefore, these TMDLs will assume that if the highest percent reduction associated with the difference between the existing loading and the LDC (TMDL) is achieved, the WQS will be attained under all other flow conditions.

4.4 Development of TMDLs using Load Duration Curves

The final step in the TMDL calculation process involves a group of additional computations that are derived from the preparation of LDCs. These computations are necessary to derive a percent reduction goal (PRG) which is one method of presenting how much bacteria loading must be reduced to meet water quality standards in the impaired watershed.

Step 1: Generate Bacteria LDCs. LDCs are similar in appearance to flow duration curves however; the ordinate is expressed in terms of a bacteria load in colony forming units per day (cfu/day). The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 ml), *E. coli* (406 cfu/100 ml), or Enterococcus (108 cfu/100 ml) expressed in terms of a load through multiplication by the continuum of flows historically observed at this site. The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the USGS,
- sorting the flow data and calculating flow exceedance percentiles for the time period and season of interest,
- obtaining the water quality data,
- matching the water quality observations with the flow data from the same date,
- multiplying the flow by the water quality parameter concentration to calculate daily loads, then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

The culmination of these steps is expressed in the following formula which is displayed as the TMDL curve on the LDC:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQC = 400 cfu /100 ml (Fecal coliform); 406 cfu/100 ml (E. coli); or 108 cfu/100 ml (Enterococcus)

*unit conversion factor = 24,465,525 ml*s / ft3*day*

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured flow, in other words, the percent of historical observations that equal or exceed the measured flow. Historical observations of bacteria concentration are paired with flow data and are plotted on the LDC. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform concentration (colonies/100 ml) by the instantaneous flow (cubic feet per second) at the same site and time, with appropriate volumetric and time unit conversions. Fecal coliform/*E. coli*/Enterococcus loads representing exceedance of water quality criteria fall above the water quality criterion line.

Only those flows and water quality samples observed in the months comprising the primary contact recreation season are used to generate the LDCs. It is inappropriate to compare single sample fecal coliform observations and instantaneous or daily flow durations to a 30-day geometric mean water quality criterion in a load duration curve.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. Yet flows do not directly correspond to runoff; high flows may occur in dry weather and runoff influence may be observed with low or moderate flows. Therefore, it is useful to provide another indicator of the presence of runoff in the load duration curve. Cleland (2003) has adopted the approach of indicating runoff influence by the difference in flow from day to day. Individual fecal coliform observations are color-labeled on the load duration curve as influenced by runoff if the flow on the day of the observation exceeded that of the previous day by 50%. This approach has the advantage of simplicity of calculation and requires no other data. An alternative approach is to color-label the individual fecal coliform observations by the amount of rainfall observed at a nearby weather station in some period preceding the water quality sample collection, as shown in Figure 4-3. Because runoff effects on bacteria concentrations are often observed for several days after a sizeable rainfall event, ODEQ adopted the practice of color-coding the water quality observations by the cumulative precipitation of the date of sample collection and previous two days at a nearby weather station. While this may not adequately characterize the nature and amount of runoff, especially that occurring upstream in large watersheds, this step will enhance the usefulness of LDCs.

Step 2: Develop LDCs with MOS. An LDC depicting slightly lower estimates than the TMDL is developed to represent the TMDL with MOS. The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some fraction of the TMDL (e.g., 10%) as the MOS. In an implicit approach conservative assumptions used in developing the TMDL are relied upon to provide a margin of safety to assure that water quality standards are attained.

For the TMDLs in this report, an explicit MOS of 10 percent of the TMDL value (10 percent of the instantaneous water quality criterion) has been selected to slightly reduce assimilative capacity in the watershed. The MOS at any given percent flow exceedance, therefore, is defined as the difference in loading between the TMDL and the TMDL with MOS.

Step 3: Calculate WLA. As previously stated, the pollutant load allocation for point sources is defined by the WLA. A point source can be either a wastewater (continuous) or

stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes permitted stormwater discharges as point source discharges and, therefore, part of the WLA.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. This concentration-based approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures" and is consistent with USEPA's Protocol for Developing Pathogen TMDLs (USEPA 2001).

WLA for WWTP. Wasteload allocations may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, wasteloads may be derived from NPDES permit limits. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility. All WLA values for each subwatershed are then summed to represent the total WLA for the watershed.

*WLA (cfu/day) = WQS * flow * unit conversion factor*

Where: WQC = 400 cfu /100 ml (Fecal coliform); 406 cfu/100 ml (E. coli); or 108 cfu/100 ml (Enterococcus)

flow (mgd) = permitted flow or design flow (if unavailable)

unit conversion factor = 37,854,120 100-ml/mg

In some cases wasteload allocations may be derived from the LDC, if the natural background concentration and base flow load, exclusive of point sources, can be assumed to be negligible. In this case, the wasteload may be set equal to the water quality target load, at some flow condition sufficiently low (e.g., 90% exceedance frequency) such that nonpoint source loads could be assumed to be negligible.

WLA for MS4s. Because a WLA for each MS4 cannot be calculated as an individual value, WLAs for MS4s are expressed as a PRG derived from the LDC for nonpoint sources. The method for estimating the percent reduction of fecal coliform loading is described in Step 8.

Step 4: Calculate LA. Load allocations can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

LA = TMDL – MOS - ∑WLA

However, to express the LA as an individual value, the LA is derived using the equation above but at the median point of the hydrologic condition class requiring the largest percent reduction as displayed in the LDCs provided in Appendix D. Thus, an alternate method for expressing the LA is to calculate a PRG for fecal coliform. Load allocations are calculated as percent reductions from current estimated loading levels required to meet water quality criteria.

Step 5: Estimate WLA Load Reduction. The WLA load reduction was not calculated because it was assumed that the continuous dischargers (NPDES permitted WWTPs) are adequately regulated under existing permits and, therefore, no WLA reduction would be required. For any MS4 permittees, the percent reduction was assumed to be the same as the nonpoint load reduction.

Step 6: Estimate LA Load Reduction. After existing loading estimates are computed for the three different hydrologic condition classes, nonpoint load reduction estimates for each WQM station are calculated by using the difference between estimated existing loading and the LDC (TMDL). This difference is expressed as a percent reduction goal and the hydrologic condition class with the largest percent reduction is selected as the critical condition and the overall PRG for the impaired water body.

SECTION 5
TMDL CALCULATIONS

5.1 Results of TMDL Calculations

The calculations and results of the TMDLs for the 303(d)-listed WQM stations in North Canadian River and Shell Creek are provided in this section. The methodology for deriving these results is specified in Section 4. The term bacteria in this section includes fecal coliform, *E. coli*, and Enterococci.

5.2 Estimated Loading and Critical Conditions

USEPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. To accomplish this, available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs. While any given WQM station may be placed on the 303(d) list for exceedances of one or more of the three bacteria indicators, a TMDL will be only be derived for one bacteria indicator based on whichever indicator necessitates the largest PRG to achieve WQS. For example, as summarized in Section 2, OK520530000030G (Shell Creek) has exceedances of the fecal coliform, *E. coli*, and Enterococci criteria (ODEQ 2002 or 2004?). To determine which bacteria indicator for this WQM station will dictate the TMDL calculations, the estimated loading and critical conditions for each bacteria indicator must be derived to identify which bacteria indicator necessitates the largest PRG to achieve WQS.

To calculate the bacteria load at the WQS, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525 ml*s / ft^3*day*) and the criterion specific to each bacteria indictor. This calculation produces the maximum bacteria load in the stream without exceeding the instantaneous standard over the range of flow conditions. The allowable bacteria (fecal coliform, *E. coli*, or enterococci) loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as a LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacteria load.

To estimate existing loading, the loads associated with all bacteria observations are paired with the flows estimated at the same site on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the estimated flow rate and a unit conversion factor of *24,465,525 ml*s / ft^3*day*. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix C. The observed bacteria loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading, and load reductions required to meet the TMDL water quality target, can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Existing loading is calculated as the 90th percentile of measured bacteria concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in

calculating the existing loading under dry conditions (flow exceedance range = 60-90 percent), the 75th percentile exceedance flow is multiplied by the 90th percentile of bacteria concentrations measured under 60-90th percentile flows.

Given that the instantaneous criterion for fecal coliform indicates that no more than 10 percent of samples should exceed 400 cfu/100 ml it is appropriate to evaluate existing loading as the 90th percentile of observed bacteria concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

After existing loading and percent reductions are calculated under each hydrologic condition class for each bacteria indicator, the largest percent reduction required dictates the critical condition and the bacteria indicator that will be used to derive the TMDL for each WQM station. Table 5-1 presents the critical condition results and percent reductions necessary for each bacteria indicator at WQM station OK520530000010-001AT. While similar load reductions are required under moist, mid-range, and dry hydrologic conditions, the critical condition occurs specifically under "Moist Conditions," when an 89 percent loading reduction for Enterococci is required to meet the WQS.

Table 5-1 Critical Conditions for Station OK520530000010-001AT

Hydrologic Condition Class*	Percent Reduction Required		
	E. coli	Fecal Coliform	Enterococci
High Flows	NA**	NA**	NA**
Moist Conditions	66%	88%	89%
Mid-Range Conditions	0%	0%	45%
Dry Conditions	0%	68%	77%
Low Flows	NA**	NA**	NA**

* Hydrologic Condition Classes are derived from Cleland 2003.

** The "high flow" (<10th percentile flow exceedance) or "low flow" (> 90th percentile flow exceedance) hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are available to reliably estimate loads under these conditions.

Based on this comparison the TMDL for North Canadian River will be derived from the LDC for Enterococci. The LDC for WQM station OK520530000010-001AT shown in Figure 5-1 indicates actual Enterococci loads are exceeding the instantaneous load of the WQS during all flow conditions. The LDCs used to estimate existing loading and identify critical conditions for *E. coli* and fecal coliform for WQM station OK520530000010-001AT similar to Figure 5-1 are provided in Appendix D. The LDCs were developed for the time period from 1997 through 2003 if data were available.

Figure 5-1 Estimated Enterococci Load and Critical Condition for Station OK520530000010-001AT (N. Canadian River)

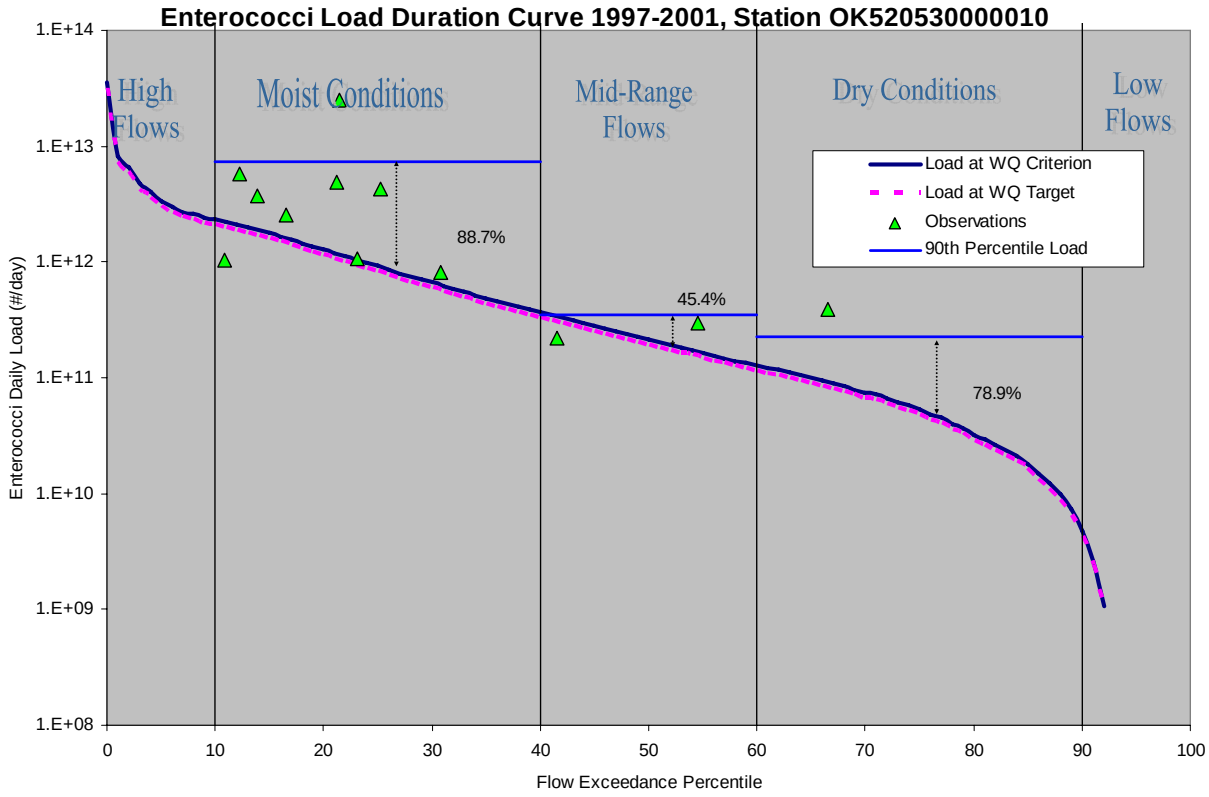


Table 5-2 presents the critical condition results and percent reductions necessary for each bacteria indicator at WQM station OK520530000030G (Shell Creek). Load reductions are required under moist and mid-range hydrologic conditions and the critical condition occurs specifically under "Mid-Range Conditions," when a 92 percent loading reduction for fecal coliform is required to meet the WQS.

Based on this comparison the TMDL for Shell Creek will be derived from the LDC for fecal coliform. The LDC for WQM station OK520530000030G shown in Figure 5-2 indicates actual fecal coliform loads are exceeding the instantaneous load of the WQS during mid-range and dry flow conditions. The LDCs used to estimate existing loading and identify critical conditions for Enterococci for WQM station OK520530000030G similar to Figure 5-2 are provided in Appendix D. The LDCs were developed for the time period from 1997 through 2003 if data were available.

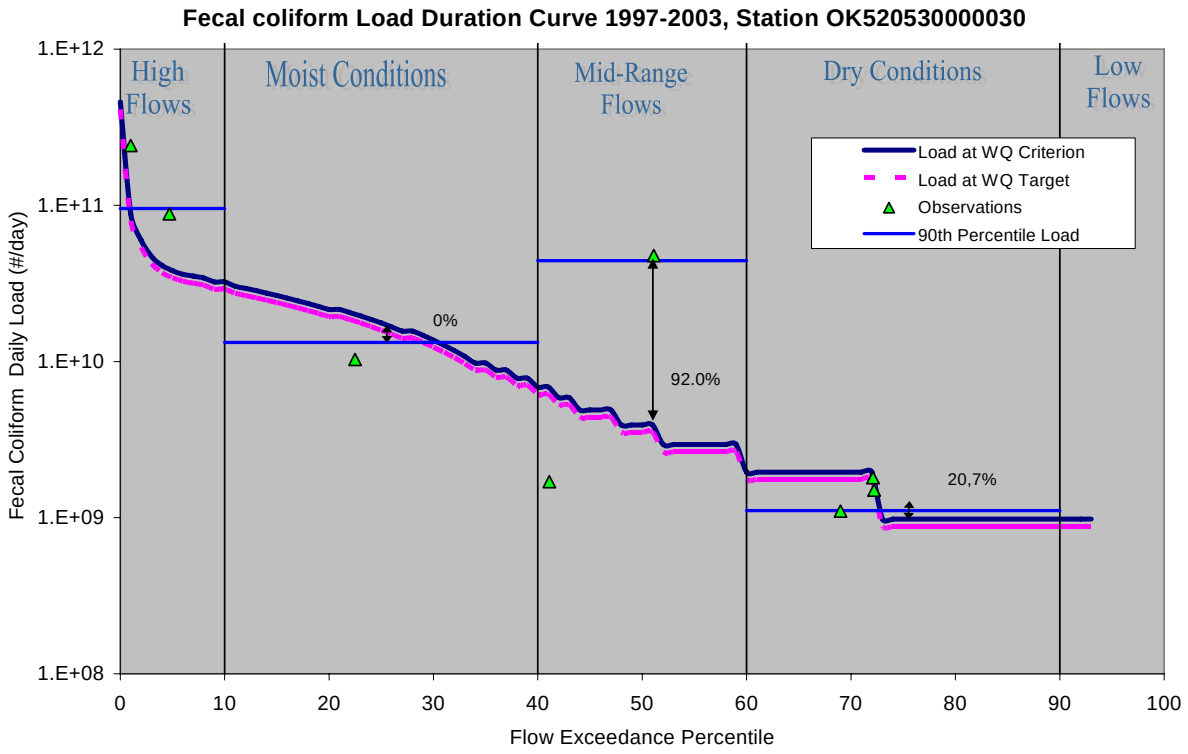
Table 5-2 Critical Condition for Station OK520530000030G

Hydrologic Condition Class*	Percent Reduction Required		
	E. coli	Fecal Coliform	Enterococci
High Flows	NA**	NA**	NA**
Moist Conditions	0%	0%	90%
Mid-Range Conditions	0%	92%	NA**
Dry Conditions	0%	21%	63%
Low Flows	NA**	NA**	NA**

* Hydrologic Condition Classes are derived from Cleland 2003.

** The "high flow" (<10th percentile flow exceedance) or "low flow" (> 90th percentile flow exceedance) hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are available to reliably estimate loads under these conditions.

Figure 5-2 Estimated Fecal Coliform Load and Critical Condition for Station OK520530000030 (Shell Creek)



The existing load for each WQM station was derived from the critical condition line depicted on the LDCs described above. Estimated existing loading is derived from the 90th percentile of observed bacteria loads corresponding to the critical condition identified at each WQM station. This estimated loading is indicative of loading from all sources including continuous point source dischargers, SSOs, failing OSWD systems, wildlife, land application fields, domestic pets, and livestock. The total estimated existing load for each station is provided in Table 5-3.

Table 5-3 Estimated Existing Loading at each WQM Station

WQM Station	Bacteria	90th Percentile Load Estimation (counts/day)	Flow Exceedance Percentile
OK520530000010-001AT	Enterococci	7.32E+12	25
OK520530000030G	Fecal coliform	4.41E+10	50

5.3 Waste Load Allocation

Table 5-4 summarizes the WLA of the NPDES-permitted facilities within the North Canadian River watershed downstream of Canton Lake. There are no NPDES WWTPs in the Shell Creek watershed. The WLA for each facility is derived from the following equation:

*WLA = WQS * flow * unit conversion factor (#/day)*

Where: WQS = 108 cfu/100ml (Enterococci)

flow (cfs) = permitted flow

unit conversion factor = 37,854,120 100-ml/mg

Table 5-4 Wasteload Allocations (WLA) for NPDES Permitted Facilities in North Canadian River Watershed

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Flow (mgd)	Bacteria	Load (cfu/day)
North Canadian River at US 81 near El Reno	OK0021911	0.5	E.coli	7.68E+09
North Canadian River at US 81 near El Reno	OK0021911	0.5	Fecal Coliform	7.57E+09
North Canadian River at US 81 near El Reno	OK0021911	0.5	Enterococci	4.09E+09

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding WQM station. When there are no NPDES WWTPs discharging into the contributing watershed of a WQM station, then the WLA for continuous point sources is zero.

5.4 Load Allocation

As discussed in Section 3, nonpoint source bacteria loading to the receiving streams of each WQM station emanate from a number of different sources. Bacteria loading from

nonpoint sources are the sole reason for nonsupport of the PBCR in Shell Creek. As discussed in Section 4, nonpoint source loading was estimated and depicted for all flow conditions using LDCs (See Figure 5-1 example and Appendix D). Figures 5-3 and 5-4, the LDCs for OK520530000010-001AT and OK520530000003G, display the relationships between the TMDL water quality target, the MOS, and the PRG that can serve as an alternative for expressing the LA. The data analysis and the LDCs demonstrate that exceedances at the WQM stations are the result of a variety of nonpoint source loading. The LAs, calculated as the difference between the TMDL, MOS, and WLA, for each WQM station are presented in Table 5-5.

5.5 Seasonal Variability

Federal regulations [40 CFR §130.7(c)(1)] require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. The TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1 through September 30. Seasonal variation was also accounted for in these TMDLs by using more than 5 years of water quality data (1997-2003) whenever possible and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.6 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include a MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable fecal coliform pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 10 percent lower than the water quality criterion for each pathogen which equates to 360 cfu/100 ml, 365.4 cfu/100 ml, and 97.2/100 ml for fecal coliform, *E. coli*, and Enterococci respectively. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced. These TMDLs incorporate an explicit MOS by using a curve representing 90 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. For consistency, the explicit MOS at each WQM station will be expressed as a numerical value derived from the same critical condition as the largest load reduction goal at the respective 25th, 50th, or 75th flow exceedance percentile (see Table 5-6).

There are other conservative elements utilized in these TMDLs that can be recognized as an implicit MOS such as:

- The use of instream bacteria concentrations to estimate existing loading; and
- The highest PRG for nonpoint sources, based on the LDC used.

This conservative approach to establishing the MOS will ensure that both the 30-day geometric mean and instantaneous bacteria standards can be achieved and maintained.

5.7 TMDL Calculations

The bacteria TMDLs for the 303(d)-listed WQM stations covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

$$TMDL = \Sigma\ WLA + \Sigma\ LA + MOS$$

For each WQM station the TMDLs presented in this report are expressed in cfu per day or as a percent reduction. To express a TMDL as an individual value, the LDC is used to derive the LA, the MOS, and the TMDL based on the median percentile of the critical condition (*i.e.,* the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each WQM station. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

$$Average\ LA = average\ TMDL - MOS - \sum WLA$$

can provide an individual value for the LA in counts per day which represents the area under the TMDL target line and above the WLA line. Percent reductions necessary to achieve the water quality target are also provided for all WQM stations as another acceptable representation of the TMDL. Like the LA, the percent reduction is derived from the median percentile of the critical condition (*i.e.*, the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). Table 5-5 summarizes the TMDLs for each WQM station, and Figures 5-3 and 5-4 present the LDCs for each station depicting the TMDL, MOS, and WLA (if applicable).

Table 5-5 TMDL Summary for WQM Stations North Canadian River and Shell Creek

WQM Station	Bacteria	WLAs (cfu/day)	LA (cfu/day or % reduction)	MOS	TMDL (cfu/day or % reduction)	Percent Reduction
OK520530000010-001AT	Enterococci	4.09E+09	8.23E+11	1.70E+11	9.98E+11	**89**
OK520530000030G	Fecal Coliform	0.00E+00	3.52E+09	1.96E+08	3.72E+09	**92**
USGS_07239450	Fecal Coliform	0.00E+00	9.60E+12	1.07E+12	1.07E+13	**86**

Analysis of the TMDL results using the load duration curve approach as shown in Table 5-6 indicate that Enterococci requires the highest percent reduction for station OK520530000010 (89%). For station OK52053000030, results show that fecal coliform requires a similar amount of reduction at 92%. For USGS_07239450, fecal coliform requires an 86% reduction.

Figure 5-3 TMDL (LDC) for North Canadian River

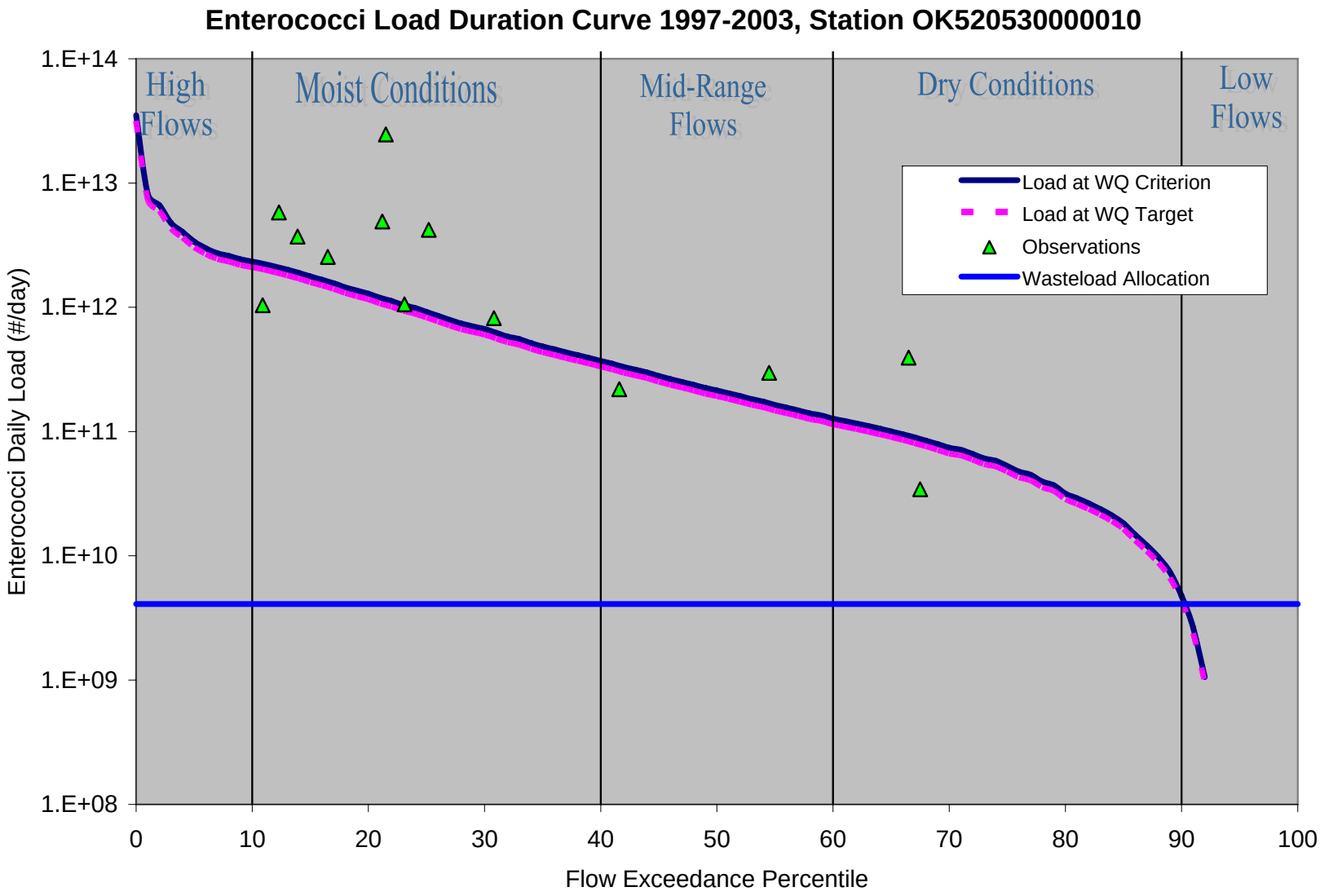
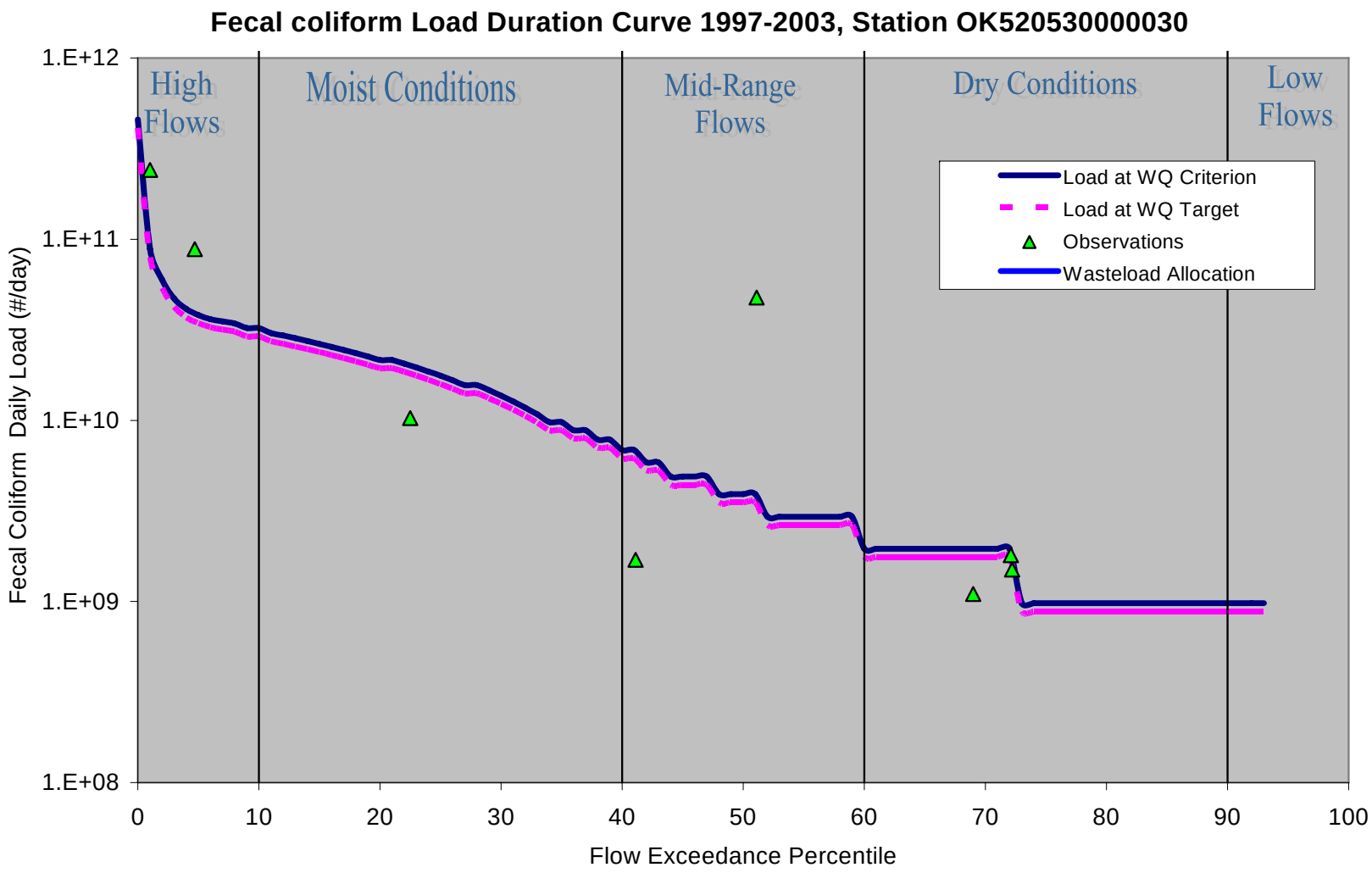


Figure 5-4 TMDL (LDC) for Shell Creek



Note: The blue line representing the wasteload allocation along the x-axis is not displayed in this graph because there are no point source discharges in this watershed.

5.8 Reasonable Assurances

ODEQ will collaborate with a host of other state agencies and local governments working within the boundaries of state and local regulations to target available funding and technical assistance to support the implementation of pollution controls and management measures. Various water quality management programs and funding sources provide reasonable assurance that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. ODEQ's Continuing Planning Process (CPP), required by the CWA §303(e)(3) and 40 CFR 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State. The CPP can be viewed from ODEQ's website at http://www.deq.state.ok.us/WQDnew/pubs/2002_cpp_final.pdf. Table 5-6 provides a partial list of the state partner agencies ODEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-6 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	http://www.okcc.state.ok.us/WQ/WQ_home.htm
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com/watchabl.htm
Oklahoma Department of Agriculture, Food, and Forestry	http://www.oda.state.ok.us/water-home.htm
Oklahoma Water Resources Board	http://www.owrb.state.ok.us/quality/index.php

Nonpoint source pollution is regulated by the Oklahoma Conservation Commission. The primary mechanisms used for management of nonpoint source pollution are incentive-based programs that support the installation of Best Management Practices and public education and outreach. Other programs include regulations and permits for CAFOs. The CAFO Act, as administered by the AEMS, provides CAFO operators the necessary tools and information to deal with the manure and wastewater animals produce so streams, lakes, ponds, and ground water sources are not polluted.

As authorized by section 402 of the CWA, the ODEQ has delegation of the NPDES program in Oklahoma, except for certain jurisdiction areas related to agriculture and the oil gas industry retained by State Department of Agriculture and Oklahoma Corporation Commission for which EPA has retained permitting authority. The NPDES program in Oklahoma is implemented via OPEES pursuant to the OPDES Act and accordance with the Agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES program (ODEQ 2005a). Implementation of point source WLAs is done through permits issued under the Oklahoma Pollution Discharge Elimination System (OPDES) program.

ODEQ also plays a key role in advancing public education about the protection and use of water resources statewide. ODEQ promotes a diligent outreach program to cities and towns,

county commissioners, the regulated community, schools, businesses and other Oklahomans who seek information on how to protect, restore and utilize the state's water resources.

SECTION 6
PUBLIC PARTICIPATION

Language to be provided by ODEQ.

SECTION 7
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APPENDIX A
AMBIENT WATER QUALITY BACTERIA DATA – 1997 TO 2003

Appendix A
ODEQ Fecal Coliform Monitoring Data 1997 - 2003

No.	WQM Station	Water Body Name	Sample Date	Bacteria Concentration (cfu/100ml)	Bacteria Indicator	Criteria (cfu/100ml)
1	USGS_07239450	North Canadian River	5/7/1997	387	FC	400
2	USGS_07239450	North Canadian River	6/12/1997	3700	FC	400
3	USGS_07239450	North Canadian River	7/9/1997	247	FC	400
4	USGS_07239450	North Canadian River	8/13/1997	3200	FC	400
5	USGS_07239450	North Canadian River	9/17/1997	29	FC	400
6	USGS_07239450	North Canadian River	5/19/1998	20	FC	400
7	USGS_07239450	North Canadian River	6/16/1998	13	FC	400
8	USGS_07239450	North Canadian River	7/8/1998	105	FC	400
9	USGS_07239450	North Canadian River	7/22/1998	84	FC	400
10	USGS_07239450	North Canadian River	8/12/1998	87	FC	400
11	USGS_07239450	North Canadian River	9/1/1998	93	FC	400
12	USGS_07239450	North Canadian River	5/26/1999	105	FC	400
13	USGS_07239450	North Canadian River	6/22/1999	1270	FC	400
14	USGS_07239450	North Canadian River	7/7/1999	240	FC	400
15	USGS_07239450	North Canadian River	8/4/1999	35	FC	400
16	USGS_07239450	North Canadian River	9/1/1999	1370	FC	400
17	USGS_07239450	North Canadian River	5/9/2000	243	FC	400
18	USGS_07239450	North Canadian River	6/14/2000	193	FC	400
19	USGS_07239450	North Canadian River	7/18/2000	85	FC	400
20	USGS_07239450	North Canadian River	8/8/2000	80	FC	400
21	USGS_07239450	North Canadian River	9/6/2000	203	FC	400
22	USGS_07239450	North Canadian River	5/2/2001	42	FC	400
23	USGS_07239450	North Canadian River	6/19/2001	84	FC	400
24	USGS_07239450	North Canadian River	7/10/2001	700	FC	400
25	USGS_07239450	North Canadian River	8/22/2001	243	FC	400
26	USGS_07239450	North Canadian River	9/11/2001	230	FC	400
27	USGS_07239450	North Canadian River	5/1/2002	55	FC	400
28	USGS_07239450	North Canadian River	6/5/2002	500	FC	400
29	USGS_07239450	North Canadian River	7/10/2002	1300	FC	400
30	USGS_07239450	North Canadian River	8/6/2002	73	FC	400
1	OK520530000010-001AT	North Canadian River	5/7/1997	387	FC	400
2	OK520530000010-001AT	North Canadian River	6/12/1997	3700	FC	400
3	OK520530000010-001AT	North Canadian River	7/9/1997	247	FC	400
4	OK520530000010-001AT	North Canadian River	8/13/1997	3200	FC	400
5	OK520530000010-001AT	North Canadian River	9/17/1997	29	FC	400
6	OK520530000010-001AT	North Canadian River	5/19/1998	20	FC	400
7	OK520530000010-001AT	North Canadian River	6/16/1998	13	FC	400
8	OK520530000010-001AT	North Canadian River	7/8/1998	105	FC	400
9	OK520530000010-001AT	North Canadian River	7/22/1998	84	FC	400
10	OK520530000010-001AT	North Canadian River	8/12/1998	87	FC	400
11	OK520530000010-001AT	North Canadian River	9/1/1998	93	FC	400
12	OK520530000010-001AT	North Canadian River	5/26/1999	105	FC	400
13	OK520530000010-001AT	North Canadian River	6/16/1999	120	FC	400
14	OK520530000010-001AT	North Canadian River	7/12/1999	750	FC	400
15	OK520530000010-001AT	North Canadian River	8/18/1999	40	FC	400
16	OK520530000010-001AT	North Canadian River	9/1/1999	1370	FC	400
17	OK520530000010-001AT	North Canadian River	5/3/2000	4100	FC	400
18	OK520530000010-001AT	North Canadian River	6/7/2000	70	FC	400
19	OK520530000010-001AT	North Canadian River	7/12/2000	90	FC	400
20	OK520530000010-001AT	North Canadian River	8/9/2000	20	FC	400
21	OK520530000010-001AT	North Canadian River	9/7/2000	50	FC	400
22	OK520530000010-001AT	North Canadian River	5/15/2001	200	FC	400

FC = Fecal Coliform
EC = Escherichia coli
ENT = Enterococci

Appendix A
ODEQ Fecal Coliform Monitoring Data 1997 - 2003

No.	WQM Station	Water Body Name	Sample Date	Bacteria Concentration (cfu/100ml)	Bacteria Indicator	Criteria (cfu/100ml)
23	OK520530000010-001AT	North Canadian River	6/6/2001	5	FC	400
24	OK520530000010-001AT	North Canadian River	7/11/2001	30	FC	400
25	OK520530000010-001AT	North Canadian River	8/22/2001	243	FC	400
26	OK520530000010-001AT	North Canadian River	9/12/2001	200	FC	400
27	OK520530000010-001AT	North Canadian River	5/14/2002	31	EC	406
28	OK520530000010-001AT	North Canadian River	6/12/2002	10	EC	406
29	OK520530000010-001AT	North Canadian River	7/17/2002	10	EC	406
30	OK520530000010-001AT	North Canadian River	8/14/2002	10	EC	406
31	OK520530000010-001AT	North Canadian River	5/12/2003	10	EC	406
32	OK520530000010-001AT	North Canadian River	5/27/2003	31	EC	406
33	OK520530000010-001AT	North Canadian River	6/16/2003	31	EC	406
34	OK520530000010-001AT	North Canadian River	6/30/2003	10	EC	406
35	OK520530000010-001AT	North Canadian River	7/21/2003	20	EC	406
36	OK520530000010-001AT	North Canadian River	8/6/2003	31	EC	406
37	OK520530000010-001AT	North Canadian River	8/25/2003	31	EC	406
38	OK520530000010-001AT	North Canadian River	9/8/2003	10	EC	406
39	OK520530000010-001AT	North Canadian River	9/29/2003	120	EC	406
40	OK520530000010-001AT	North Canadian River	5/14/2002	110	ENT	108
41	OK520530000010-001AT	North Canadian River	6/12/2002	250	ENT	108
42	OK520530000010-001AT	North Canadian River	7/17/2002	190	ENT	108
43	OK520530000010-001AT	North Canadian River	8/14/2002	6000	ENT	108
44	OK520530000010-001AT	North Canadian River	5/12/2003	10	ENT	108
45	OK520530000010-001AT	North Canadian River	5/27/2003	500	ENT	108
46	OK520530000010-001AT	North Canadian River	6/16/2003	110	ENT	108
47	OK520530000010-001AT	North Canadian River	6/30/2003	150	ENT	108
48	OK520530000010-001AT	North Canadian River	7/21/2003	700	ENT	108
49	OK520530000010-001AT	North Canadian River	8/6/2003	300	ENT	108
50	OK520530000010-001AT	North Canadian River	8/25/2003	160	ENT	108
51	OK520530000010-001AT	North Canadian River	9/8/2003	60	ENT	108
52	OK520530000010-001AT	North Canadian River	9/29/2003	200	ENT	108
1	OK520530000030G	Shell Creek	5/15/2000	100	FC	400
2	OK520530000030G	Shell Creek	6/19/2000	1000	FC	400
3	OK520530000030G	Shell Creek	7/24/2000	5000	FC	400
4	OK520530000030G	Shell Creek	8/28/2000	470	FC	400
5	OK520530000030G	Shell Creek	5/8/2001	1000	FC	400
6	OK520530000030G	Shell Creek	6/12/2001	300	FC	400
7	OK520530000030G	Shell Creek	8/21/2001	330	FC	400
8	OK520530000030G	Shell Creek	9/26/2001	390	FC	400
9	OK520530000030G	Shell Creek	8/28/2000	228	EC	406
10	OK520530000030G	Shell Creek	5/8/2001	959	EC	406
11	OK520530000030G	Shell Creek	6/12/2001	131	EC	406
12	OK520530000030G	Shell Creek	7/17/2001	160	EC	406
13	OK520530000030G	Shell Creek	8/21/2001	205	EC	406
14	OK520530000030G	Shell Creek	9/26/2001	300	EC	406
15	OK520530000030G	Shell Creek	8/28/2000	260	ENT	108
16	OK520530000030G	Shell Creek	5/8/2001	1000	ENT	108
17	OK520530000030G	Shell Creek	6/12/2001	1000	ENT	108
18	OK520530000030G	Shell Creek	8/21/2001	260	ENT	108
19	OK520530000030G	Shell Creek	9/26/2001	170	ENT	108

FC = Fecal Coliform
EC = Escherichia coli
ENT = Enterococci

APPENDIX B
NPDES PERMIT DISCHARGE MONITORING REPORT DATA

Appendix B
NPDES Permit Discharge Monitoring Report Data 1998-2003

Permit	Monthly Avg Concentration	Daily Maximum Concentration	Outfall	Report Date	Parameter Code	Parameter	MQAV	MQMX	Parameter Code	Parameter
OK0021911	240	720	1	5/31/1998	74055	FC	0.678	0.727	50050	Flow
OK0021911	1	1	1	6/30/1998	74055	FC	0.442	0.787	50050	Flow
OK0021911	1967	5900	1	7/31/1998	74055	FC	0.5	0.663	50050	Flow
OK0021911	1	1	1	8/31/1998	74055	FC	0.432	0.562	50050	Flow
OK0021911	433	1300	1	9/30/1998	74055	FC	0.297	0.449	50050	Flow
OK0021911	1	1	1	5/31/1999	74055	FC	0.691	0.789	50050	Flow
OK0021911	1	1	1	6/30/1999	74055	FC	0.689	0.866	50050	Flow
OK0021911	1	1	1	7/31/1999	74055	FC	0.677	0.838	50050	Flow
OK0021911	4	8	1	8/31/1999	74055	FC	0.603	0.676	50050	Flow
OK0021911	1.7	5	1	9/30/1999	74055	FC	0.551	0.671	50050	Flow
OK0021911	2	5	1	5/31/2000	74055	FC	0.693	0.821	50050	Flow
OK0021911	1	3	1	6/30/2000	74055	FC	0.733	0.937	50050	Flow
OK0021911	1	1	1	7/31/2000	74055	FC	0.745	0.928	50050	Flow
OK0021911	40.3	110	1	8/31/2000	74055	FC	0.639	0.703	50050	Flow
OK0021911	667	2000	1	9/30/2000	74055	FC	0.556	0.636	50050	Flow
OK0021911	120	270	1	5/31/2001	74055	FC	0.669	0.928	50050	Flow
OK0021911	1	1	1	6/30/2001	74055	FC	0.735	1.319	50050	Flow
OK0021911	1	2	1	7/31/2001	74055	FC	0.616	0.928	50050	Flow
OK0021911	2	4	1	8/31/2001	74055	FC	0.586	0.846	50050	Flow
OK0021911	20.3	43	1	9/30/2001	74055	FC	0.59	0.753	50050	Flow
OK0021911	1.6	3	1	5/31/2002	74055	FC	0.618	0.781	50050	Flow
OK0021911	1	3	1	6/30/2002	74055	FC	0.643	0.847	50050	Flow
OK0021911	4	12	1	7/31/2002	74055	FC	0.594	0.786	50050	Flow
OK0021911	1	2	1	8/31/2002	74055	FC	0.594	0.864	50050	Flow
OK0021911	1	1	1	9/30/2002	74055	FC	0.581	0.781	50050	Flow
OK0021911	1	1	1	5/31/2003	74055	FC	0.554	0.749	50050	Flow
OK0021911	0	0	1	6/30/2003	74055	FC	0.532	0.657	50050	Flow
OK0021911	1	1	1	7/31/2003	74055	FC	0.548	0.763	50050	Flow
OK0021911	0	1	1	8/31/2003	74055	FC	0.6	0.797	50050	Flow
OK0021911	1	1	1	9/30/2003	74055	FC	0.565	0.67	50050	Flow

APPENDIX C
ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix C
Estimated Flow Exceedance Percentiles by WQM Station (cfs)

Estimated Flow Exceedance Percentiles by WQM Station (cfs)			
	Flows projected from USGS gage stations		
	07239700	07239500	07239450
	OK520530000030G	OK520530000010-001AT	USGS07239450
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
5	3.9	1280	1090
10	3.3	883	943
15	2.7	670	820
20	2.2	487	686
25	1.8	348	521
30	1.4	253	399
35	1	183	280
40	0.7	140	185
45	0.5	106	142
50	0.4	81	112
55	0.3	62	88
60	0.2	48	72
65	0.2	38	56
70	0.2	28	47
75	0.1	20	39
80	0.1	12	34
85	0.1	6.9	29
90	0.1	1.8	22
95	0	0	14

Appendix C
Estimated Flow Exceedance Percentiles by WQM Station (cfs)

Estimated Flow Exceedance Percentiles by WQM Station (cfs)			
	Flows projected from USGS gage stations		
	07239700	07239500	07239450
	OK520530000030G	OK520530000010-001AT	USGS07239450
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	46.8	13300	8430
1	9	3080	1960
2	6.1	2520	1480
3	4.8	1810	1260
4	4.2	1530	1140
5	3.9	1280	1090
6	3.7	1130	1030
7	3.6	1030	1000
8	3.5	980	980
9	3.3	920	958
10	3.3	883	943
11	3.1	846	911
12	3	803	885
13	2.9	761	858
14	2.8	717	839
15	2.7	670	820
16	2.6	631	792
17	2.5	592	771
18	2.4	548	749
19	2.3	516	721
20	2.2	487	686
21	2.2	452	650
22	2.1	425	625
23	2	395	594
24	1.9	374	557
25	1.8	348	521
26	1.7	323	501
27	1.6	300	465
28	1.6	280	440
29	1.5	266	418
30	1.4	253	399
31	1.3	236	379
32	1.2	220	354
33	1.1	210	323
34	1	195	300
35	1	183	280
36	0.9	174	254
37	0.9	164	231
38	0.8	156	212
39	0.8	148	199
40	0.7	140	185
41	0.7	133	173
42	0.6	125	166
43	0.6	119	156
44	0.5	113	149
45	0.5	106	142
46	0.5	100	136
47	0.5	95	132
48	0.4	90	126
49	0.4	85	119
50	0.4	81	112

Appendix C
Estimated Flow Exceedance Percentiles by WQM Station (cfs)

Estimated Flow Exceedance Percentiles by WQM Station (cfs)			
	Flows projected from USGS gage stations		
	07239700	07239500	07239450
	OK520530000030G	OK520530000010-001AT	USGS07239450
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
51	0.4	77	105
52	0.3	73	99
53	0.3	69	95
54	0.3	66	91
55	0.3	62	88
56	0.3	59	84
57	0.3	56	81
58	0.3	53	78
59	0.3	51	75
60	0.2	48	72
61	0.2	46	68
62	0.2	44	65
63	0.2	42	62
64	0.2	40	60
65	0.2	38	56
66	0.2	36	54
67	0.2	34	51
68	0.2	32	50
69	0.2	30	49
70	0.2	28	47
71	0.2	27	45
72	0.2	25	43
73	0.1	23	42
74	0.1	22	41
75	0.1	20	39
76	0.1	18	38
77	0.1	17	37
78	0.1	15	36
79	0.1	14	35
80	0.1	12	34
81	0.1	11	33
82	0.1	10	32
83	0.1	9	31
84	0.1	8	30
85	0.1	6.9	29
86	0.1	5.6	29
87	0.1	4.6	27
88	0.1	3.7	26
89	0.1	2.8	24
90	0.1	1.8	22
91	0.1	1	21
92	0.1	0.4	19
93	0.1	0	17
94	0	0	15
95	0	0	14
96	0	0	12
97	0	0	11
98	0	0	9.1
99	0	0	5.5
100	0	0	3.3

Appendix C
Flow Projection Information

WQM Station	Area (sq. mi.)	CN	Rain (inches)	Down Stream Gages	# of US Gages	Upstream Gages
OK520530000030G	22.3	45.40	35.6	07239700	0	
OK520530000010-001AT	13,089	26.80	20.7	07239700	0	
USGS07239450	13,089	72.29	20.7	07239500	0	

Appendix C
General Methodology for Estimating Flow at WQM Stations

A flow duration curve will be developed using existing USGS measured flow where the data exist at the same location as the Oklahoma WQM station or by estimating flow for WQM stations with no corresponding flow record. Flow data to support flow duration curves and load duration curves will be derived for each Oklahoma WQM station in the following priority:

i) In cases where a USGS flow gage coincides with, or occurs within one-half mile upstream or downstream of the Oklahoma WQM station.

   a. If simultaneous daily flow data matching the water quality sample date are available, these flow measurements will be used.

   b. If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, the gaps in the flow record will be filled, or the record will be extended, by estimating flow based on measured streamflows at a nearby gage. First, the most appropriate nearby stream gage is identified. All flow data are first log-transformed to linearize the data because flow data are highly skewed. Linear regressions are then developed between 1) daily streamflow at the gage to be filled/extended, and 2) streamflow at all gages within 95 miles that have at least 300 daily flow measurements on matching dates. The station with the best flow relationship, as indicated by the highest r-squared value, is selected as the index gage. R-squared indicates the fraction of the variance in flow explained by the regression. The regression is then used to estimate flow at the gage to be filled/extended from flow at the index station. Flows will not be estimated based on regressions with r-squared values less than 0.25, even if that is the best regression. In some cases, it will be necessary to fill/extend flow records from two or more index gages. The flow record will be filled/extended to the extent possible based on the best index gage (highest r-squared value), and remaining gaps will be filled from the next best index gage (second highest r-squared value), and so forth.

ii) In the case no coincident flow data are available for a WQM station, but flow gage(s) are present upstream and/or downstream, flows will be estimated for the WQM station from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the National Resources Conservation Service (NRCS) runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Parsons will then identify all the USGS gage stations upstream and downstream of the subwatersheds with 303(d) listed WQM stations.

   a. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset (NED) digital elevation model, and National Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.

b. The watershed average curve number is calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds*. The soil hydrologic group is extracted from NRCS STATSGO soil data, and land use category from the National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers are estimated at the 30-meter resolution of the NLCD grid as shown in Table 7. The average curve number is then calculated from all the grid cells within the delineated watershed.

c. The average rainfall is calculated for each watershed from gridded average annual precipitation datasets for the period 1971-2000 (Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/, created 20 Feb 2004).

Table B-1 Runoff Curve Numbers for Various Land Use Categories and Hydrologic Soil Groups

NLCD Land Use Category	Curve number for hydrologic soil group			
	A	B	C	D
0 in case of zero	100	100	100	100
11 Open Water	100	100	100	100
12 Perennial Ice/Snow	100	100	100	100
21 Low Intensity Residential	54	70	80	85
22 High Intensity Residential	77	85	90	92
23 Commercial/Industrial/Transportation	89	92	94	95
31 Bare Rock/Sand/Clay	25	25	25	25
32 Quarries/Strip Mines/Gravel Pits	0	0	0	0
33 Transitional	75	80	85	90
41 Deciduous Forest	37	48	57	63
42 Evergreen Forest	45	48	73	80
43 Mixed Forest	43	65	76	82
51 Shrubland	40	51	63	70
61 Orchards/Vineyards/Other	55	69	78	83
71 Grasslands/Herbaceous	40	51	63	70
81 Pasture/Hay	35	56	70	77
82 Row Crops	64	75	82	85
83 Small Grains	64	75	82	85
84 Fallow	40	51	63	70
85 Urban/Recreational Grasses	49	69	79	84
91 Woody Wetlands	100	100	100	100
92 Emergent Herbaceous Wetlands	100	100	100	100

d. Flow at the ungaged site is calculated from the gaged site. The NRCS runoff curve number equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (1)$$

where:

Q = runoff (inches)

P = rainfall (inches)

S = potential maximum retention after runoff begins (inches)

I_a = initial abstraction (inches)

If P < 0.2, Q = 0. Initial abstraction has been found to be empirically related to S by the equation

$$I_a = 0.2*S \qquad (2)$$

Thus, the runoff curve number equation can be rewritten:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (3)$$

S is related to the curve number (CN) by:

$$S = \frac{1000}{CN} - 10 \qquad (4)$$

e. First, S is calculated from the average curve number for the gaged watershed. Next, the daily historic flows at the gage are converted to depth basis (as used in equations 1 and 3) by dividing by its drainage area, then converted to inches. Equation 3 is then solved for daily precipitation depth of the gaged site, P_{gaged}. The daily precipitation depth for the ungaged site is then calculated as the precipitation depth of the gaged site multiplied by the ratio of the long-term average precipitation in the watersheds of the ungaged and gaged sites:

$$P_{ungaged} = P_{gaged}\left(\frac{M_{ungaged}}{M_{gaged}}\right) \qquad (5)$$

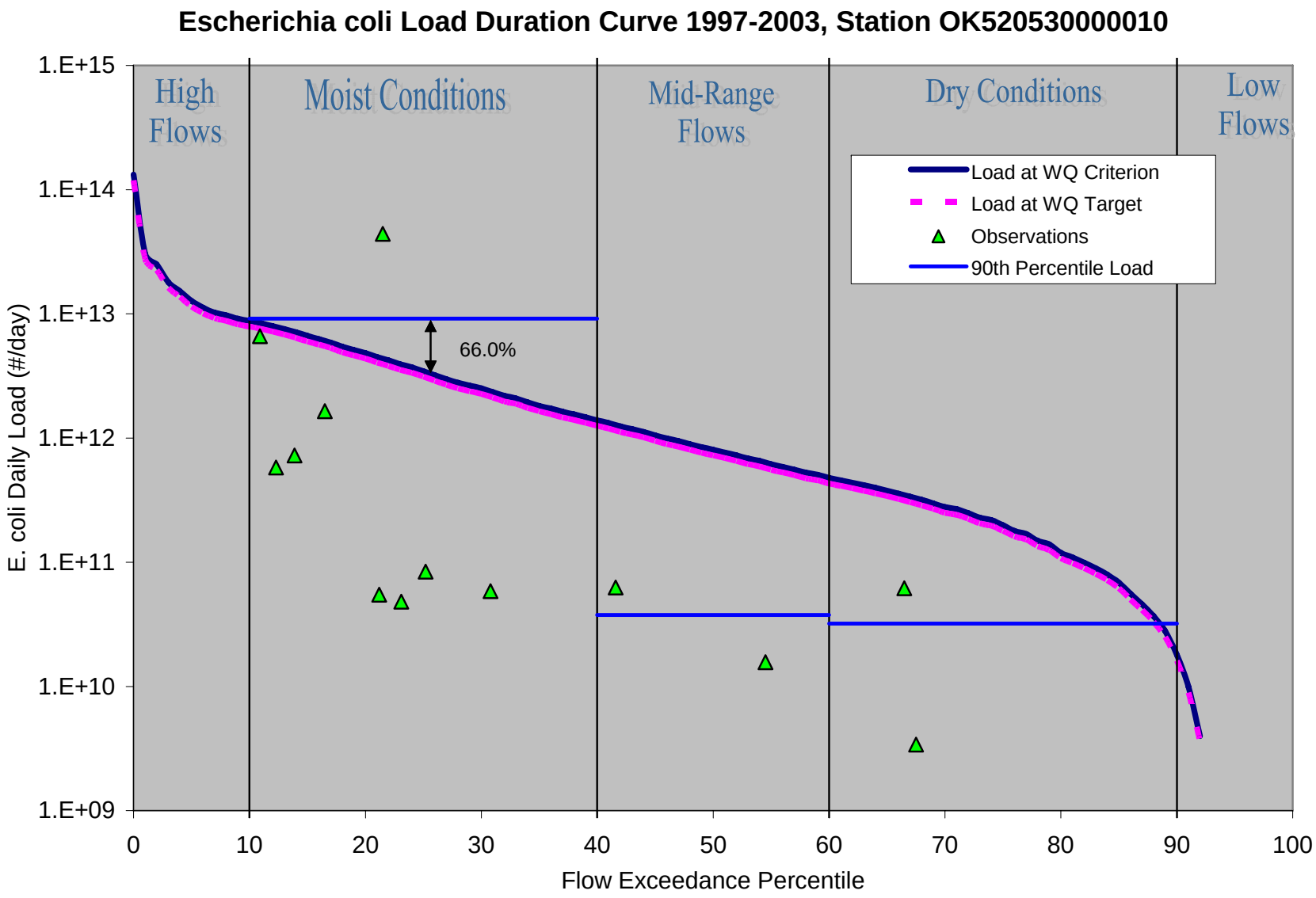
where M is the mean annual precipitation of the watershed in inches. The daily precipitation depth for the ungaged watershed, along with the average curve number of the ungaged watershed, are then used to calculate the depth equivalent daily flow Q of the ungaged site. Finally, the volumetric flow rate at

the ungaged site is calculated by multiplying by the area of the watershed of the ungaged site and converted to cubic feet.

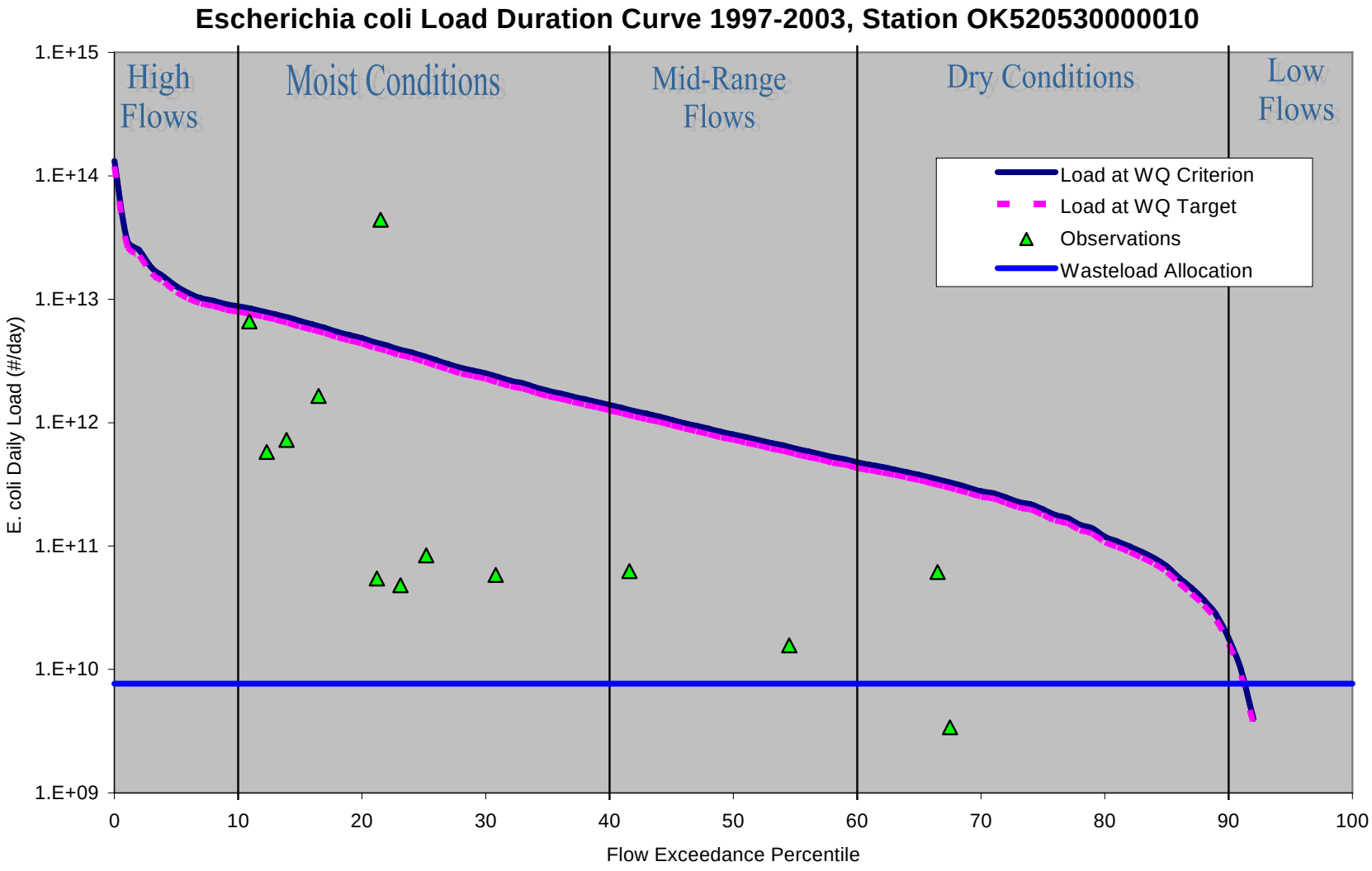
iii) In the rare case where no coincident flow data are available for a WQM station and no gages are present upstream or downstream, flows will be estimated for the WQM station from a gage on an adjacent watershed of similar size and properties, via the same procedure described above for upstream or downstream gages.

APPENDIX D
LDCS FOR CRITICAL CONDITIONS AND TMDLS OF ADDITIONAL BACTERIA INDICATORS

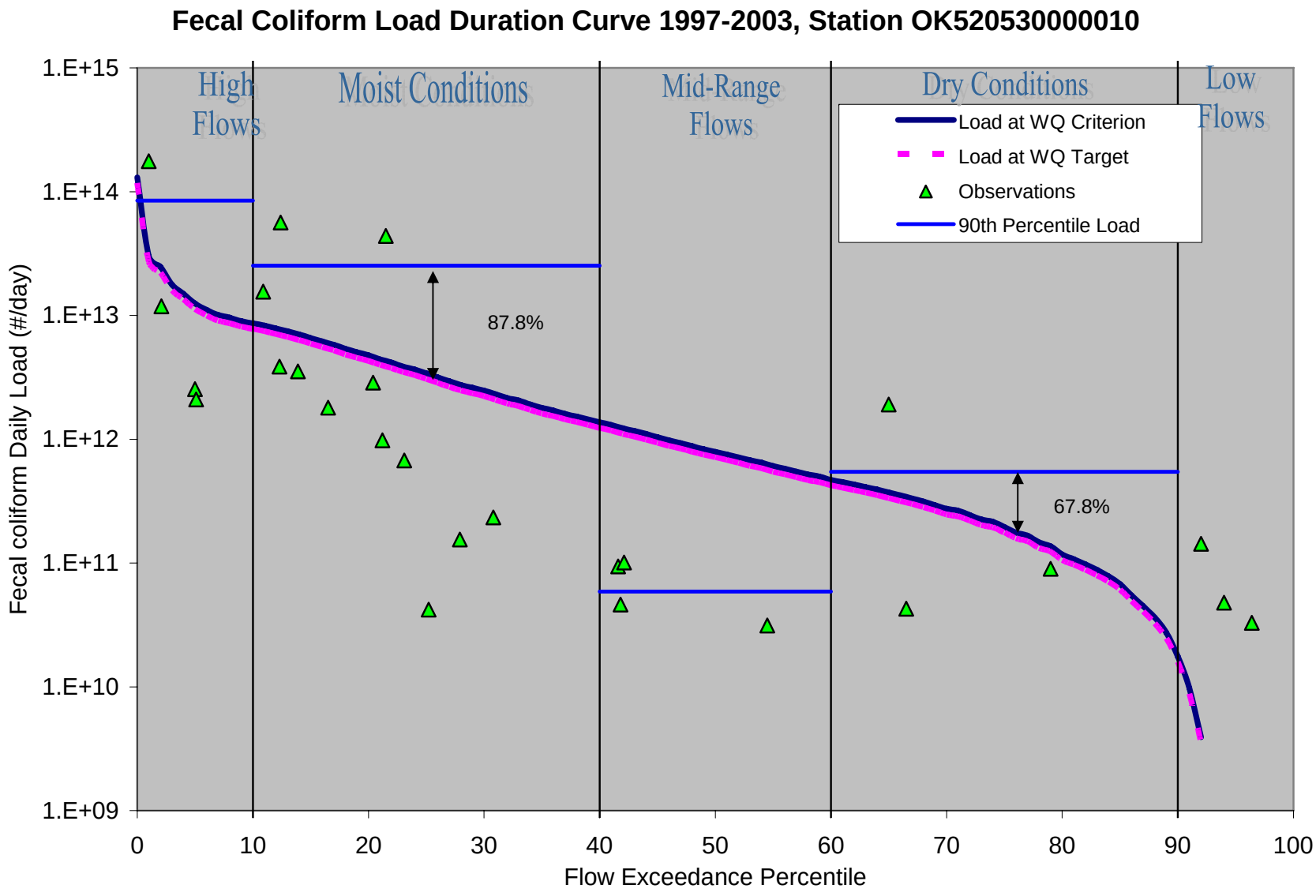
Estimated *E. coli* Load and Critical Conditions for North Canadian River



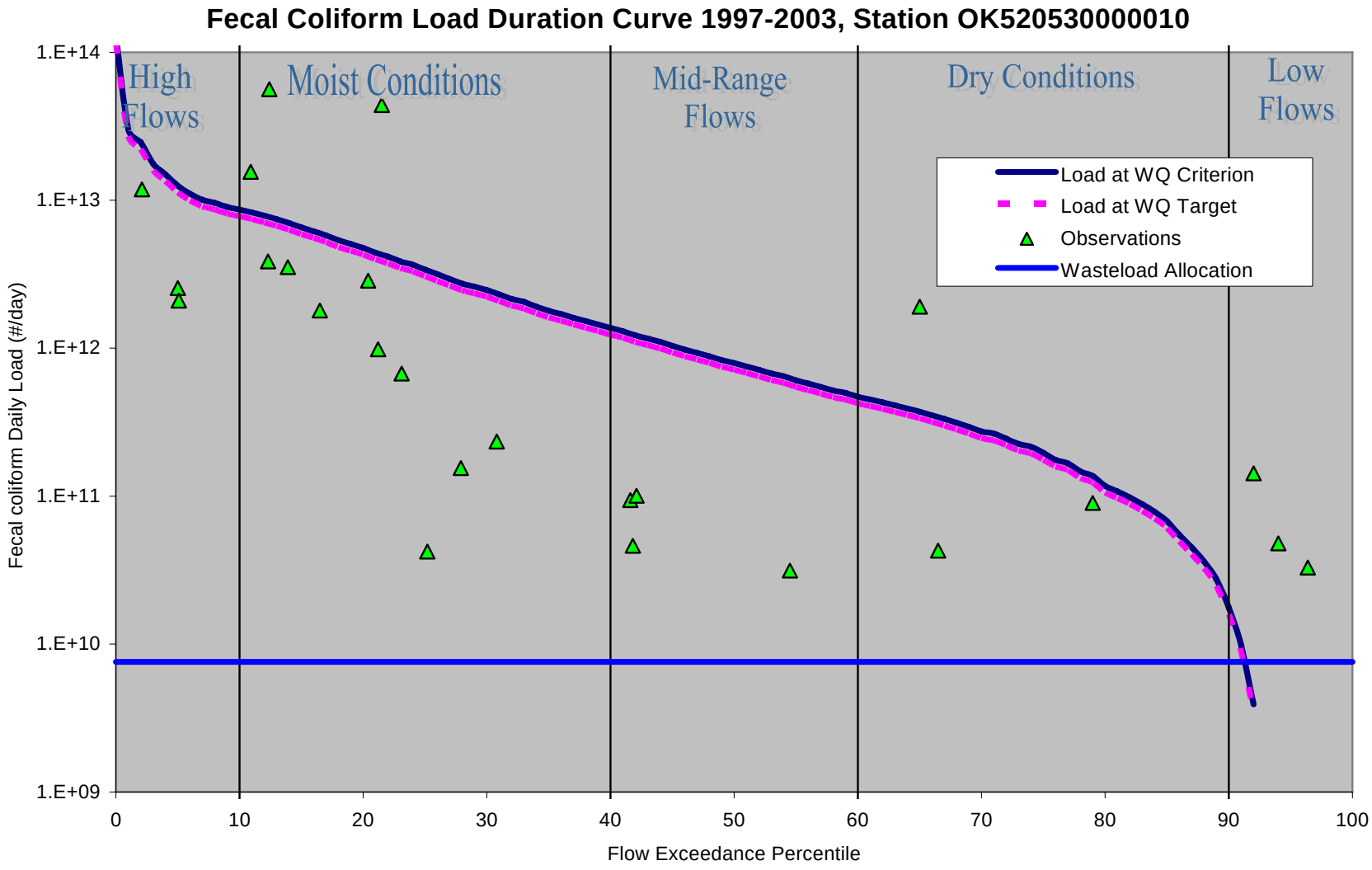
E. coli TMDL (LDC) for North Canadian River



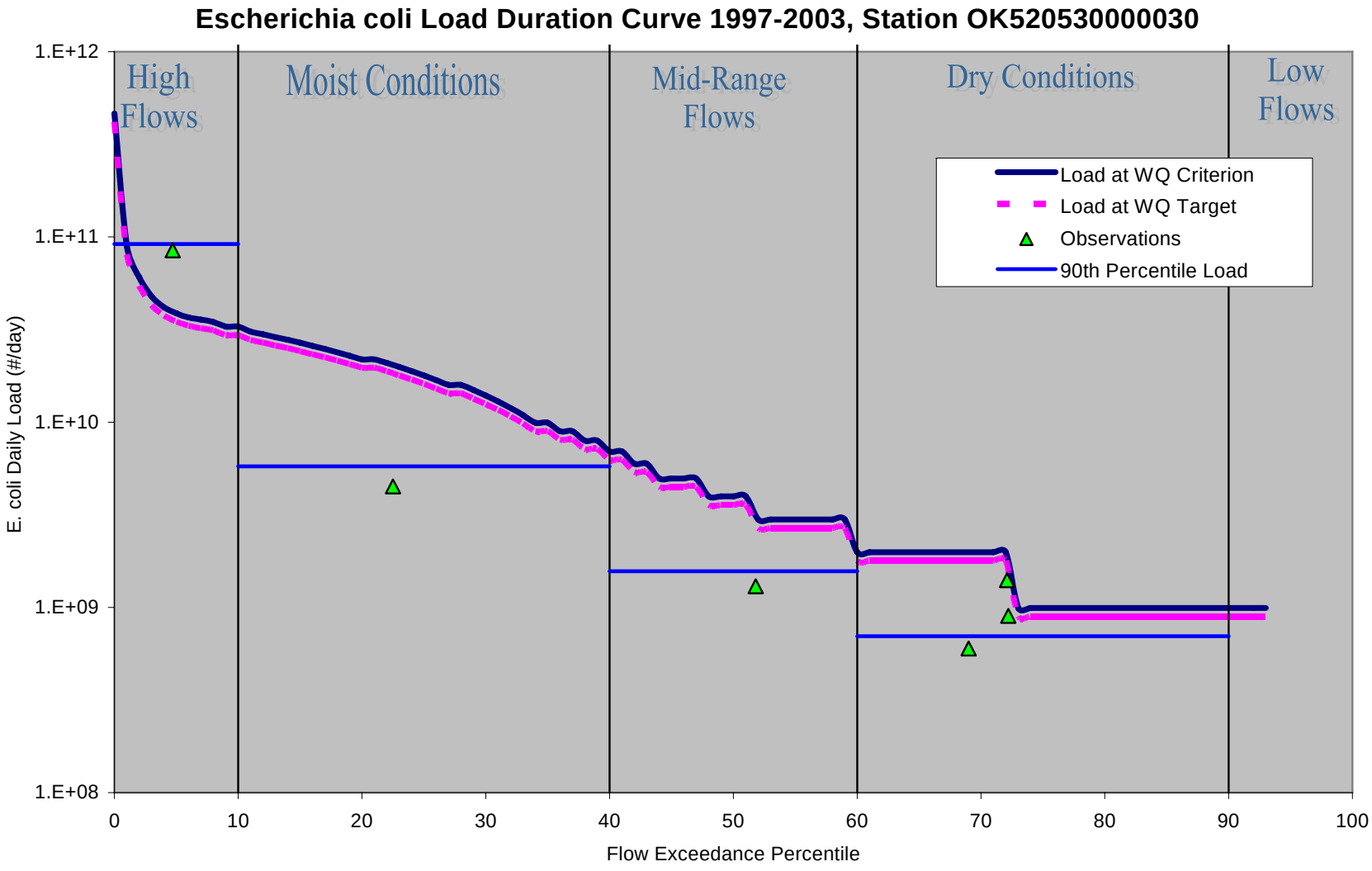
Estimated Fecal Coliform Load and Critical Conditions for North Canadian River



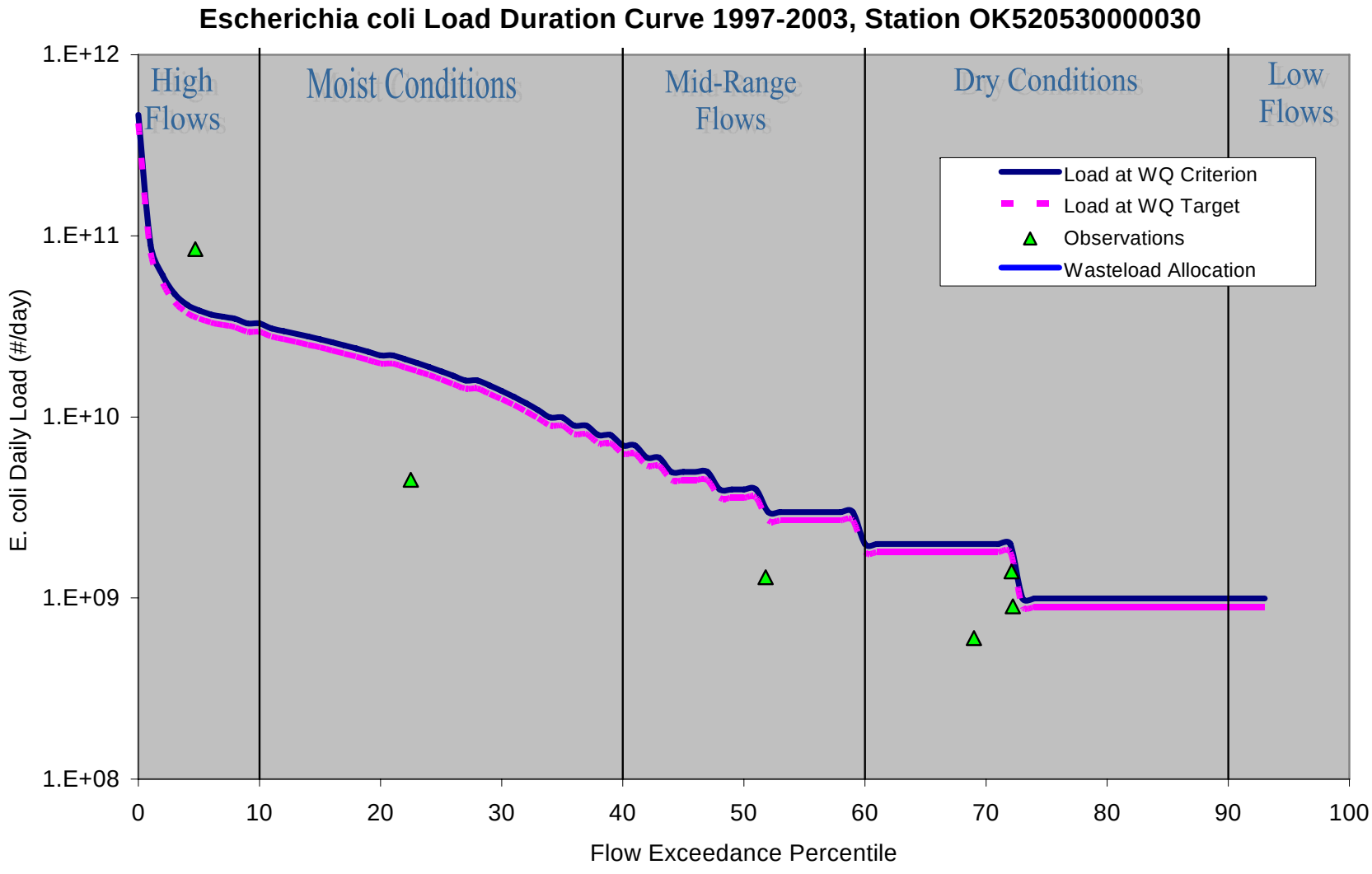
Fecal Coliform TMDL (LDC) for North Canadian River



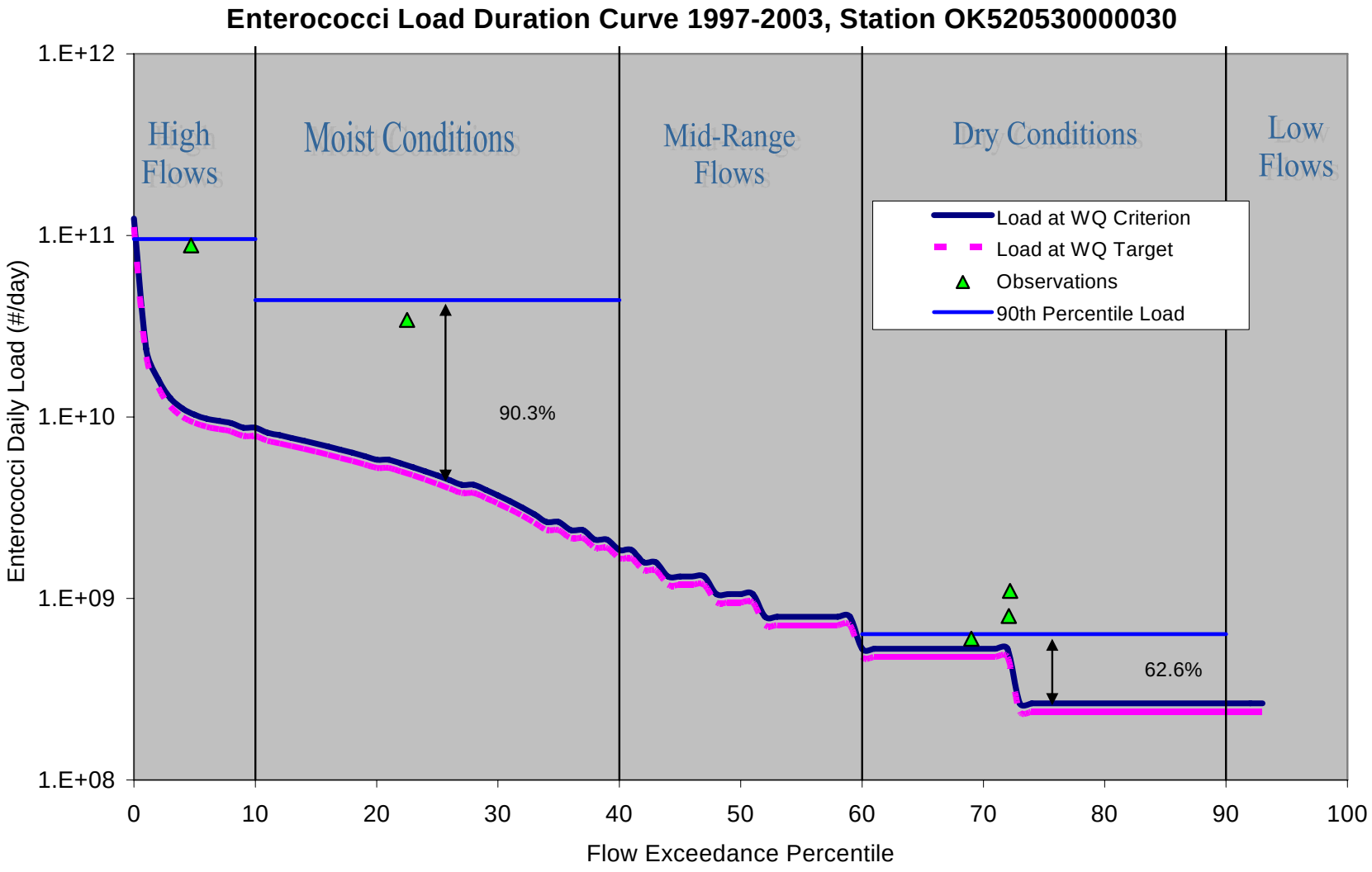
Estimated *E. coli* Load and Critical Conditions for Shell Creek



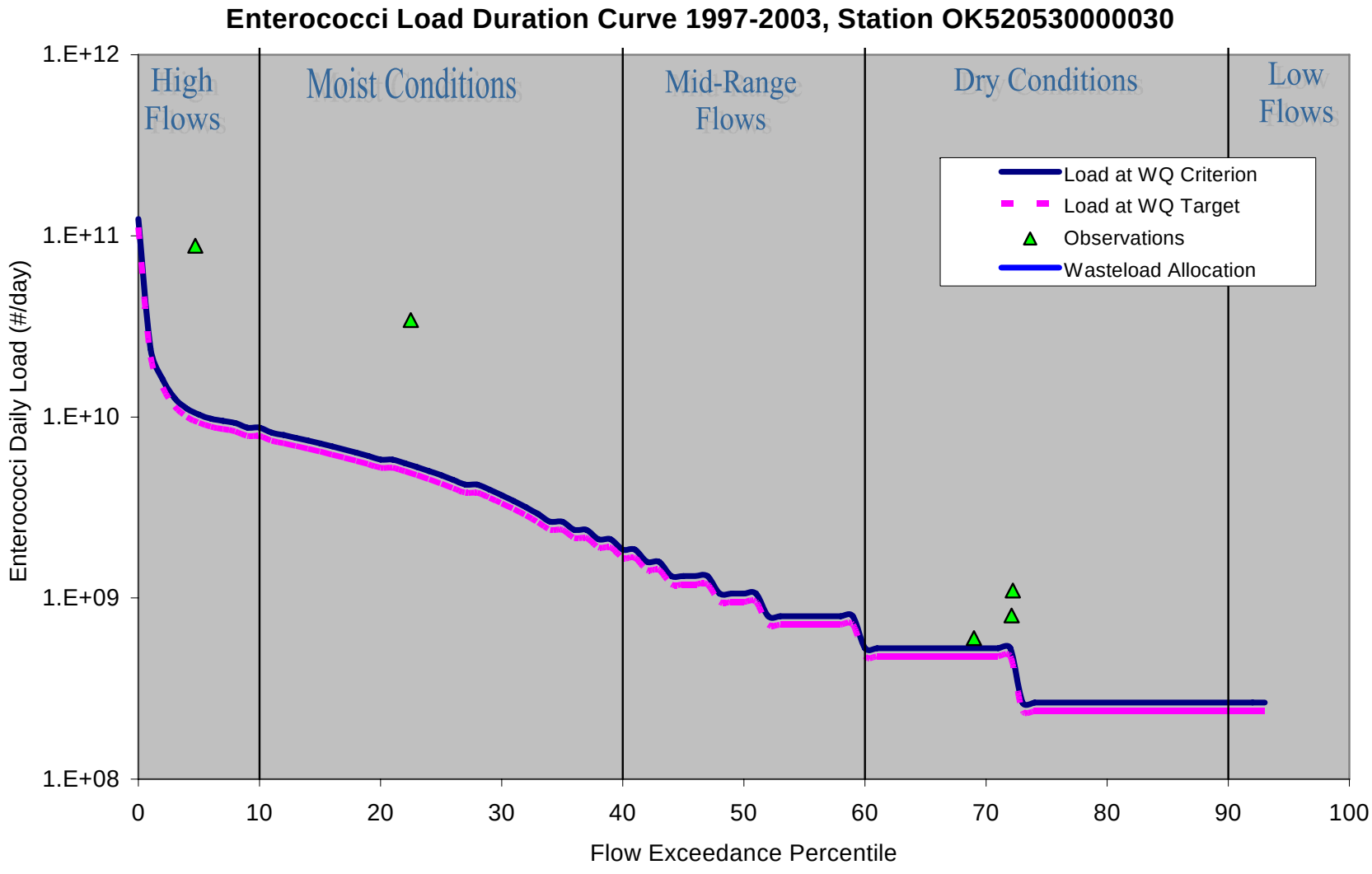
E. coli TMDL (LDC) for Shell Creek



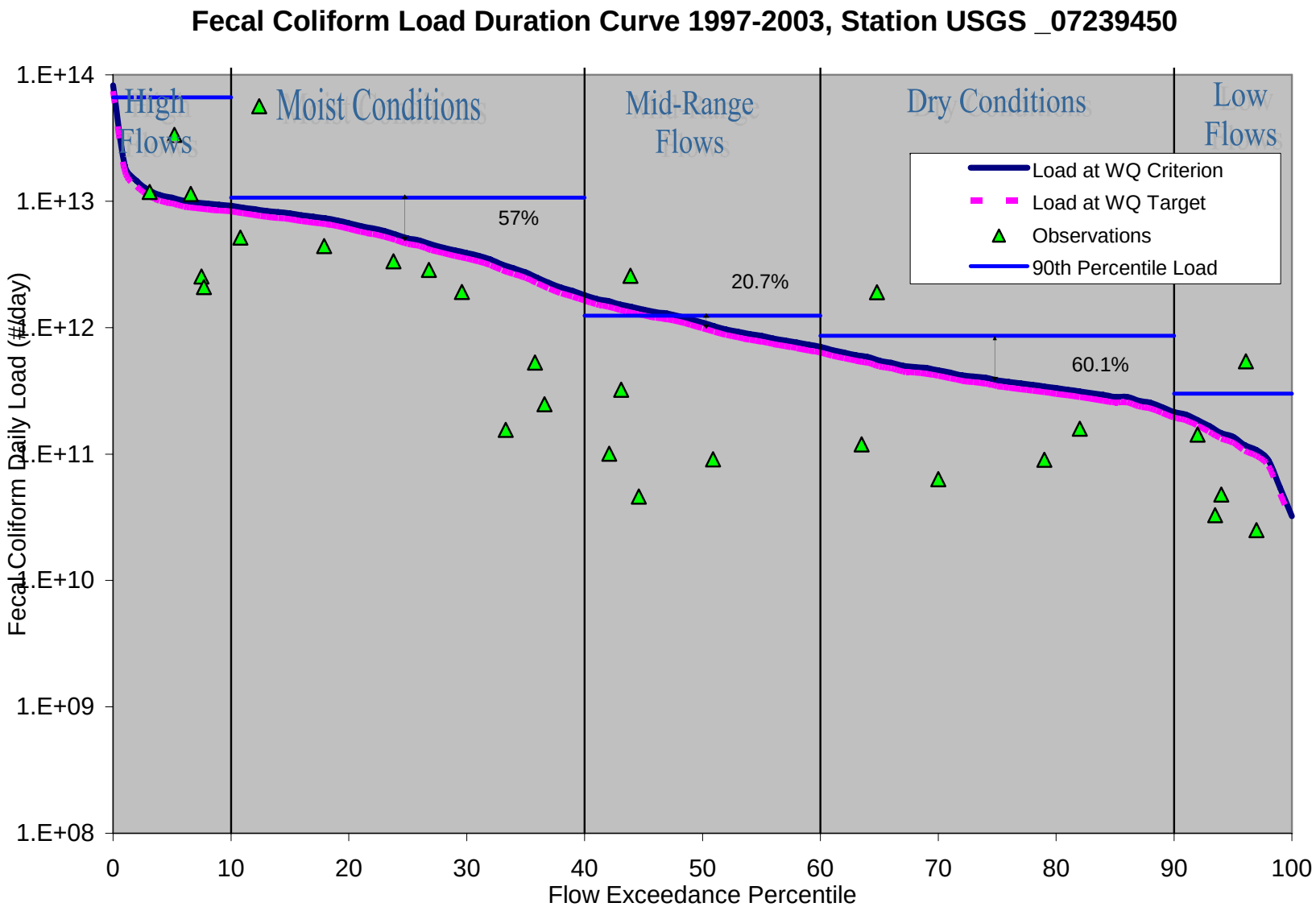
Estimated Enterococci Load and Critical Conditions for Shell Creek



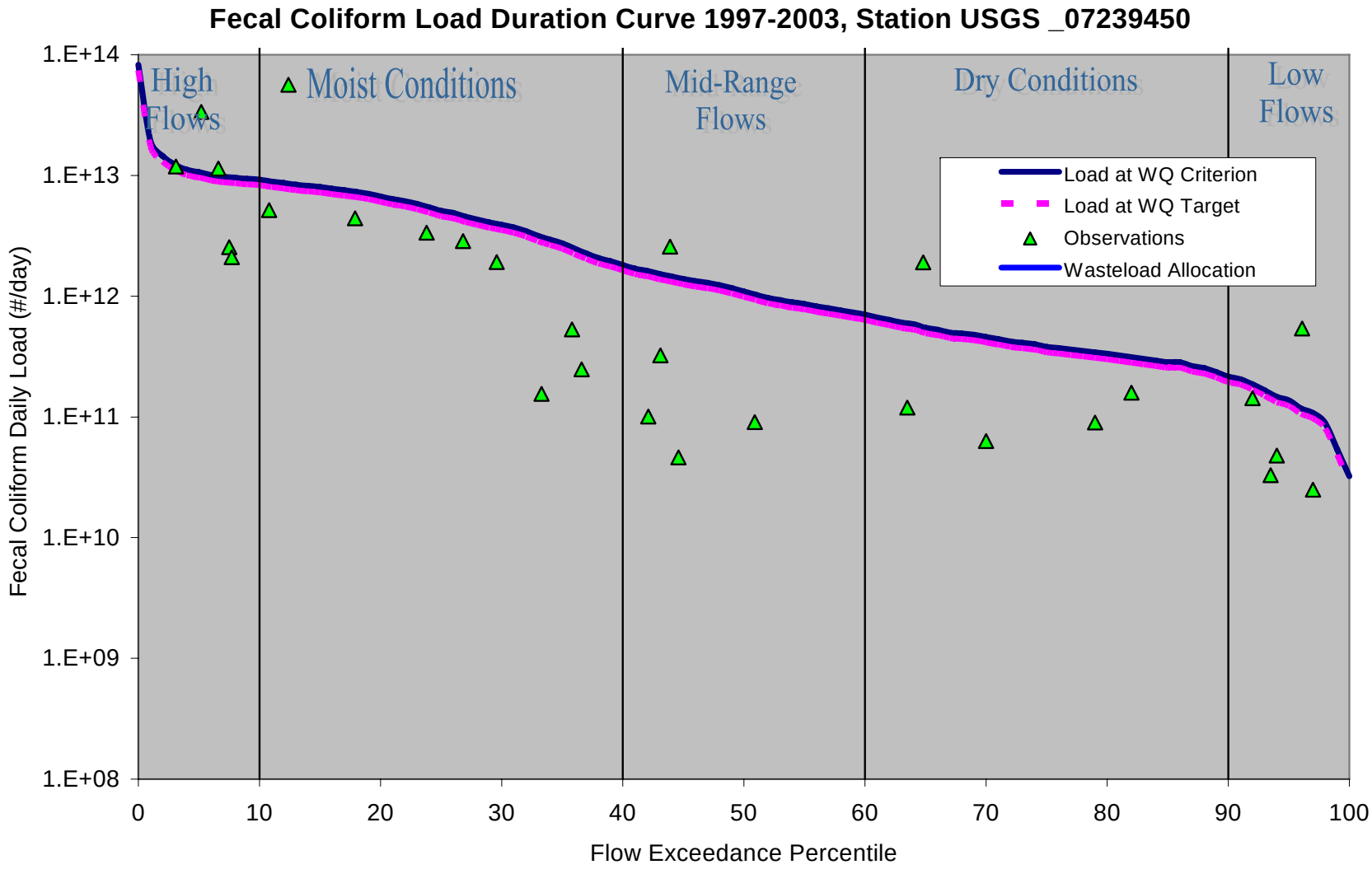
Enterococci TMDL (LDC) for Shell Creek



Estimated Fecal Coliform Load and Critical Conditions for North Canadian River



Fecal Coliform TMDL (LDC) for North Canadian River



APPENDIX E
STATE OF OKLAHOMA ANTIDEGREDATION POLICY

Appendix E
State of Oklahoma Antidegradation Policy

785:45-3-1. Purpose; Antidegradation policy statement

(a) Waters of the state constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the State of Oklahoma to protect all waters of the state from degradation of water quality, as provided in OAC 785:45-3-2 and Subchapter 13 of OAC 785:46.

785:45-3-2. Applications of antidegradation policy

(a) Application to outstanding resource waters (ORW). Certain waters of the state constitute an outstanding resource or have exceptional recreational and/or ecological significance. These waters include streams designated "Scenic River" or "ORW" in Appendix A of this Chapter, and waters of the State located within watersheds of Scenic Rivers. Additionally, these may include waters located within National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges, and waters which contain species listed pursuant to the federal Endangered Species Act as described in 785:45-5-25(c)(2)(A) and 785:46-13-6(c). No degradation of water quality shall be allowed in these waters.

(b) Application to high quality waters (HQW). It is recognized that certain waters of the state possess existing water quality which exceeds those levels necessary to support propagation of fishes, shellfishes, wildlife, and recreation in and on the water. These high quality waters shall be maintained and protected.

(c) Application to beneficial uses. No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed.

(d) Application to improved waters. As the quality of any waters of the state improve, no degradation of such improved waters shall be allowed.

785:46-13-1. Applicability and scope

(a) The rules in this Subchapter provide a framework for implementing the antidegradation policy stated in OAC 785:45-3-2 for all waters of the state. This policy and framework includes three tiers, or levels, of protection.

(b) The three tiers of protection are as follows:

(1) Tier 1. Attainment or maintenance of an existing or designated beneficial use.

(2) Tier 2. Maintenance or protection of High Quality Waters and Sensitive Public and Private Water Supply waters.

(3) Tier 3. No degradation of water quality allowed in Outstanding Resource Waters.

(c) In addition to the three tiers of protection, this Subchapter provides rules to implement the protection of waters in areas listed in Appendix B of OAC 785:45. Although Appendix B areas are not mentioned in OAC 785:45-3-2, the framework for protection of Appendix B areas is similar to the implementation framework for the antidegradation policy.

(d) In circumstances where more than one beneficial use limitation exists for a waterbody, the most protective limitation shall apply. For example, all antidegradation policy implementation rules applicable to Tier 1 waterbodies shall be applicable also to Tier 2 and Tier 3 waterbodies or areas, and implementation rules applicable to Tier 2 waterbodies shall be applicable also to Tier 3 waterbodies.

(e) Publicly owned treatment works may use design flow, mass loadings or concentration, as appropriate, to calculate compliance with the increased loading requirements of this section if those flows, loadings or concentrations were approved by the Oklahoma Department of Environmental Quality as a portion of Oklahoma's Water Quality Management Plan prior to the application of the ORW, HQW or SWS limitation.

785:46-13-2. Definitions

The following words and terms, when used in this Subchapter, shall have the following meaning, unless the context clearly indicates otherwise:

"Specified pollutants" means

(A) Oxygen demanding substances, measured as Carbonaceous Biochemical Oxygen Demand (CBOD) and/or Biochemical Oxygen Demand (BOD);

(B) Ammonia Nitrogen and/or Total Organic Nitrogen;

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

(E) Such other substances as may be determined by the Oklahoma Water Resources Board or the permitting authority.

785:46-13-3. Tier 1 protection; attainment or maintenance of an existing or designated beneficial use

(a) General.

(1) Beneficial uses which are existing or designated shall be maintained and protected.

(2) The process of issuing permits for discharges to waters of the state is one of several means employed by governmental agencies and affected persons which are designed to attain or maintain beneficial uses which have been designated for those waters. For example, Subchapters 3, 5, 7, 9 and 11 of this Chapter are

rules for the permitting process. As such, the latter Subchapters not only implement numerical and narrative criteria, but also implement Tier 1 of the antidegradation policy.

(b) Thermal pollution. Thermal pollution shall be prohibited in all waters of the state. Temperatures greater than 52 degrees Centigrade shall constitute thermal pollution and shall be prohibited in all waters of the state.

(c) Prohibition against degradation of improved waters. As the quality of any waters of the state improves, no degradation of such improved waters shall be allowed.

785:46-13-4. Tier 2 protection; maintenance and protection of High Quality Waters and Sensitive Water Supplies

(a) General rules for High Quality Waters. New point source discharges of any pollutant after June 11, 1989, and increased load or concentration of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "HQW". Any discharge of any pollutant to a waterbody designated "HQW" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load or concentration of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load or concentration would result in maintaining or improving the level of water quality which exceeds that necessary to support recreation and propagation of fishes, shellfishes, and wildlife in the receiving water.

(b) General rules for Sensitive Public and Private Water Supplies. New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS". Any discharge of any pollutant to a waterbody designated "SWS" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load will result in maintaining or improving the water quality in both the direct receiving water, if designated SWS, and any downstream waterbodies designated SWS.

(c) Stormwater discharges. Regardless of subsections (a) and (b) of this Section, point source discharges of stormwater to waterbodies and watersheds designated "HQW" and "SWS" may be approved by the permitting authority.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "HQW" or "SWS" in Appendix A of OAC 785:45.

785:46-13-5. Tier 3 protection; prohibition against degradation of water quality in outstanding resource waters

(a) General. New point source discharges of any pollutant after June 11, 1989, and increased load of any pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "ORW" and/or "Scenic River", and in any waterbody located within the watershed of any waterbody designated with the limitation "Scenic River". Any discharge of any pollutant to a waterbody designated "ORW" or "Scenic River" which would, if it occurred, lower existing water quality shall be prohibited.

(b) Stormwater discharges. Regardless of 785:46-13-5(a), point source discharges of stormwater from temporary construction activities to waterbodies and watersheds designated "ORW" and/or "Scenic River" may be permitted by the permitting authority. Regardless of 785:46-13-5(a), discharges of stormwater to waterbodies and watersheds designated "ORW" and/or "Scenic River" from point sources existing as of June 25, 1992, whether or not such stormwater discharges were permitted as point sources prior to June 25, 1992, may be permitted by the permitting authority; provided, however, increased load of any pollutant from such stormwater discharge shall be prohibited.

(c) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "ORW" in Appendix A of OAC 785:45, provided, however, that development of conservation plans shall be required in sub-watersheds where discharges or runoff from nonpoint sources are identified as causing or significantly contributing to degradation in a waterbody designated "ORW".

(d) LMFO's. No licensed managed feeding operation (LMFO) established after June 10, 1998 which applies for a new or expanding license from the State Department of Agriculture after March 9, 1998 shall be located...[w]ithin three (3) miles of any designated scenic river area as specified by the Scenic Rivers Act in 82 O.S. Section 1451 and following, or [w]ithin one (1) mile of a waterbody [2:9-210.3(D)] designated in Appendix A of OAC 785:45 as "ORW".

785:46-13-6. Protection for Appendix B areas

(a) General. Appendix B of OAC 785:45 identifies areas in Oklahoma with waters of recreational and/or ecological significance. These areas are divided into Table 1, which includes national and state parks, national forests, wildlife areas, wildlife management areas and wildlife refuges; and Table 2, which includes areas which contain threatened or endangered species listed as such by the federal government pursuant to the federal Endangered Species Act as amended.

(b) Protection for Table 1 areas. New discharges of pollutants after June 11, 1989, or increased loading of pollutants from discharges existing as of June 11, 1989, to waters within the boundaries of areas listed in Table 1 of Appendix B of OAC 785:45 may be

approved by the permitting authority under such conditions as ensure that the recreational and ecological significance of these waters will be maintained.

(c) Protection for Table 2 areas. Discharges or other activities associated with those waters within the boundaries listed in Table 2 of Appendix B of OAC 785:45 may be restricted through agreements between appropriate regulatory agencies and the United States Fish and Wildlife Service. Discharges or other activities in such areas shall not substantially disrupt the threatened or endangered species inhabiting the receiving water.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds located within areas listed in Appendix B of OAC 785:45.